DISCOVERY

A Monthly Popular Journal of Knowledge

Vol. IX, No. 99. MARCH, 1928. PRICE 1s. NET

EXCAVATING THE HIPPODROME OF CONSTANTINOPLE.

CHIEF CONTENTS.

NOTE.—*The publishers have acquired the goodwill and connexions of* **Modern Science** *and* **Conquest.**

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Editorial Notes.

The excavation of the Hippodrome in Constantinople, of which we publish an account this month, has revealed details of the most imposing of these ancient structures. While no hippodrome in Italy or Greece has as yet been properly excavated, the special interest of the Constantinople example lies in its containing a complete record of the city's history for a thousand years. The work is under the supervision of Mr. Casson, who contributes our article, and is the first to be undertaken with the full permission and approval of the Turkish Government. Excavating in towns is difficult under the best of conditions, and without official support it would have been impossible in Constantinople to explore the ground adequately. One of the buildings not yet definitely identified was unearthed in the open space adjoining St. Sophia; it appears to fit the position of the Octagon, a building which played a prominent part in the great Nika revolt that was ruthlessly suppressed by Justinian. As was to be expected, the discovery of coinage has been particularly marked, and exact dating of the layers uncovered has been largely made possible by this aid.

* * * * *

It is unnecessary to add to the pointed summing-up with which the Lord Chief Justice concluded last month the libel case of Mr. Mitchell-Hedges, the explorer, who brought an action for libel against a London newspaper. The wider issue involved is whether such valuable bodies as the Royal Geographical Society are serving their best interests by allowing members the right to initials that are obviously open to abuse. Apart from the type of writer and lecturer who may use membership to impose on the credulity of the public, there are instances of abuse which are not so generally known. Only a few weeks before the law suit under discussion, we chanced to meet an assistant master at a typical preparatory school, who seriously suggested that, in the absence of a university degree, the "F.R.G.S." was valuable as a "qualification." The point arose quite by chance in a discussion on the status of contributors to *Discovery*, when we made perhaps exaggerated light of these particular initials; but in our acquaintance's opinion they had proved of material advantage in securing appointments. The statement issued by the Society on 20th February does not seem to us to meet the situation as adequately as could be desired.

* * * * *

The latest report of the Medical Research Council contains some interesting details of new investigations on vitamins, in particular on vitamin "D." There can be no reasonable doubt, from all the evidence now available, that the great majority of our population is suffering from a deficiency in these essential parts of food, a deficiency of which the economic loss is incalculable. The report gives a technical account of work by Dr. Rosenheim and Mr. T. A. Webster, that has led to the artificial manufacture of vitamin "D," the anti-rachitic vitamin until recently obtained only as a product of a living substance. This has been effected by treating a sterol with ultra-violet light, a research that was touched upon by Mr. C. A. Cooper in our February number. "For the first time"—to quote the report—"it becomes easy to examine the properties of this vitamin without complications introduced by the presence of its common associates in Nature." This will obviously aid investigation at many points, and interesting developments are likely to follow.

* * * * *

We heartily endorse the appeal on behalf of the Stonehenge Fund, which Viscount Grey made at luncheon given last month by the Lord Mayor of

London. About £16,000 is still required to protect Stonehenge from unsightly surroundings, and the Government has no power to buy land surrounding national monuments except such as is "necessary to protect them against predatory animals." In suggesting that when we speak of Salisbury Plain we think of something not only flat but open, Lord Grey recalled some lines in which Wordsworth spoke of "Sarum's naked plain." The word "naked" is the one to be emphasized, and the features that inspired this impression are now in danger. Nearly fifty years ago, when Lord Grey first visited Salisbury Plain, he saw on the horizon an object that field-glasses showed was the spire of Salisbury Cathedral. "To have one of the greatest monuments of the religion on which our civilization is based just in view of the monument of some prehistoric cult is," he said, "an interesting feature that ought to be preserved."

* * * * *

The need for finding some cure for the depressed condition of the agricultural industry has lately received so much attention of a political kind, that there is a refreshing note in some observations just advanced by Mr. Borlase Matthews. Himself a practical farmer engaged in large-scale operations, he suggests that agricultural production can be improved through industrialization by means of electricity. The results are contained in his new book "Electro-farming," where the case for electrification and its possibilities on a seventy-acre farm is worked out. Ignoring the convenience of electricity and treating the matter on a purely commercial basis, it is estimated that electric lighting would save £1 5*s.*; electric milking would save £11 13*s.*; cream separating by electricity would save £5 16*s.*; water pumping would save £6 8*s.* 4*d.*; an electrically-operated chaff-cutter would save £1 11*s.* 6*d.* This means a substantial saving even after 15 per cent. on the installation cost has been laid aside for interest and depreciation. This improved state of affairs has been brought about by only *partial* electrification, and every day further applications to agriculture—such as electric soil heating—are being evolved.

* * * * *

The dispute over the discoveries at Glozel has not yet ended, and M. Reinach continues to use every opportunity to express his disagreement with the verdict of the inquiry Commission. The article he published in *Discovery* was itself a masterly array of such facts as support his views, and he is now making the most of his opponents' failure to explain the occurrence of the site. The latest round in the "Battle" has been fired in a letter to *The Times* by Sir Arthur Evans, who gives new evidence that the objects were of recent date. The chief technician of M. Reinach's own museum, it appears, has now been sent by the French Minister of Education to make an expert examination of the objects; and he shows that the cylindrical borings of the stone implements have been executed by steel tools, the engraving equally by metal points, and that the finished surfaces of the stone axe blades also bear the undoubted scratchings of metal files. If this new report should be substantiated by other experts, the only remaining problem would seem to be a matter for the police.

* * * * *

In the early hours of 9th February, an image transmitted by wireless from Mr. Baird's London laboratory was picked up in New York. Television has thus triumphed over distance, and the Atlantic is conquered by yet another means of communication. Following this achievement, the Television Society has appropriately launched a journal called *Television*, which presents many aspects of this new science. It is, however, to be regretted that the first of a series of articles on future developments should be devoted to "Television in Warfare." Probably few discoveries are made which do not have undesirable as well as useful applications, but Mr. Baird himself has publicly expressed the hope that other peaceful uses may be found for his invention. In making this criticism we are not overlooking the argument that every additional horror should serve to make war less readily undertaken—in our opinion an argument closely related to the fallacy that preparation for war is the best defence against it.

* * * * *

The first winter air cruise, organized by Imperial Airways and due to leave London on 27th February, will cover over 5,500 miles before the "Silver Wing" machine returns to this country on 1st April. After a night's stay in Paris, the party proceeds on the second day to Bordeaux and Biarritz. The flight along the Pyrenees affords one of the most wonderful mountain panoramas in the world. After an extensive tour over Spanish territory, Tangiers is reached across the Straits of Gibraltar. Fez, Algiers and Tunis are among a dozen places to be visited in the north of Africa, before the Mediterranean is again crossed for Catania in Sicily, and thence to Naples and Rome. The organizers are confident of keeping to their time-table, as the weather conditions should be more stable than those prevailing on the cross-channel route. It is entertaining to note that this first air cruise should follow so closely the centenary of Jules Verne.

The Hippodrome of Constantinople.

By S. Casson, M.A.

The first excavations carried out with official consent on the Hippodrome of Constantinople, under the author's direction, have revealed details of the most imposing example of ancient buildings of this type. The internal history of this great city for a thousand years is now yielding to the spade of the excavator.

EXCAVATIONS in the centre of a thickly populated city are rarely carried out, because of their obvious difficulty. The projected excavation of the ancient market-place of Athens by American archaeologists involves the clearance of many modern buildings and, in consequence, much preliminary expense. The excavation of the Forum at Rome was more easy since the site was largely an open space before clearance, but, even so, much had to be pulled down. Usually the ancient sites of classical lands are deserted, like Mycenae, Olympia, or Delos. It is then, the more to be wondered at that the Turkish Government gave permission for the excavation of a site in the heart of Stamboul, since the bulk of the site is covered by roadways and a small park, which are in continual use. That they did give this permission is due solely to an appreciation by the authorities of the scientific value of such work and to their desire to give opportunity for their monuments to be scientifically examined.

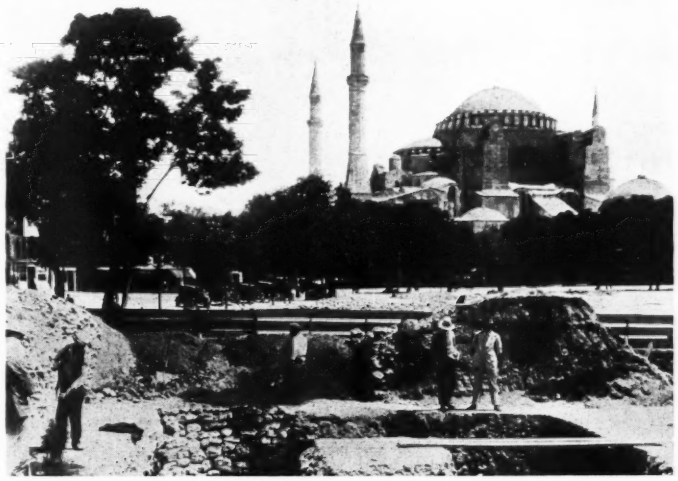


FIG. 1.

THE BATHS OF ZEUXIPPOS, NEAR THE MOSQUE OF AHMET.

Clearance of the space between St. Sophia and the Mosque of Ahmet has revealed a structure that proved to be the Baths of Zeuxippos. They were connected to the Hippodrome by a bridge.

The circumstances of such an excavation are naturally bound to be interesting, and all work on such a site is certain to be productive. The Hippodrome has a double value from the point of view of the archaeologist. Firstly, it was the most imposing example in antiquity of buildings of this type. No Hippodrome in the ancient world had so long or so exciting a life; and, curiously enough, although volumes have been written about the races and games of the ancient world, no single example of a Hippodrome either in Greece or Italy has yet been properly excavated. But, secondly, this Hippodrome in particular is of profound importance, because it is the epitome of the whole of the internal history of this great city for a thousand years, and because it was adorned and readorned by emperor after emperor with works of art brought from the dying cities of ancient Greece. Constantinople had no great central Forum as Rome had, and her Hippodrome served the double purpose of a place where public games and spectacles were seen, and also where all the chief events of the public life of the city, processions of triumphant generals, dethronements of unpopular emperors, riots of rival factions, and public punishments of malefactors, took place.

It was with no little excitement, then, that we turned the first sod of soil in March of last year. To archaeologists this initial ceremony is not merely a ceremony. Once the shovel is in the soil a formality of great value is achieved. The director or learned body responsible for the enterprise has staked a claim, and nothing can subsequently give away that claim to others except the expressed will and decision of the excavator himself.

Our task was a heavy one, because no previous investigators had left any work upon which we could base our plans. The dimensions themselves of the

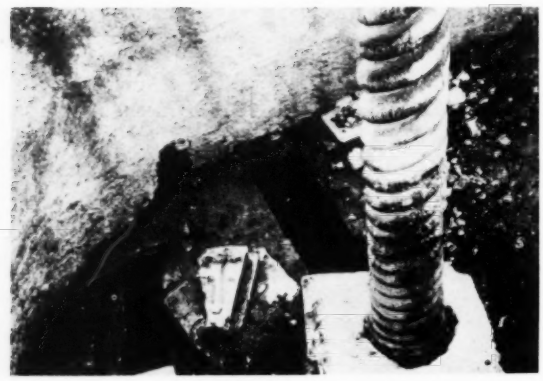


FIG. 2.
THE SERPENT COLUMN AFTER EXCAVATION.
Originally erected as a war memorial to the Greeks who beat the Persians in 479 B.C., this bronze column was afterwards used as a fountain. Water spouted from the serpent's three mouths, and the channel was found during excavation.

Hippodrome were utterly unknown, and all we had were guesses of various experts which varied sometimes by hundreds of feet; all that was left visible of the building was the row of three well-known monuments down the centre—the two great obelisks and the bronze serpent-column from Delphi—and a vast substructure in brick and stone at the curved end of the building which, in antiquity, was known as the "Sling" or "Sphendone."

But if we lacked information we had a surplus of advice. All the wiseacres of Stamboul crowded to the scene of action from the very first day and never left us. All, without exception, assumed that our talk of the Hippodrome was just our gentle bluff. It was *gold* that we were after, and someone had certainly told us where it was!—*they* could see through us; why, hadn't they been digging all over Stamboul for gold for generations? and hadn't they found it, too, every now and then? and now, here were these wealthy foreigners, with every conceivable implement and no police restrictions and goodness knows how many secret plans of hidden treasure in their pockets! They would not have a fiasco, as did the humble Turk who lived in the house at the corner of the square and dug so deep in his cellar that the house fell in on top of him. No, these foreigners would do the thing properly and in a few days, or at most weeks, they would get all the gold and jewels and be off!

These were the thoughts of nearly every humble citizen of Stamboul. One came to me one day and showed me a piece of gold ore: "when you have finished here," he said, "come to my farm in Anatolia and help me dig my gold mine; I can see you are an expert." Another came and told me of a place "quite near by" where there were treasures galore. "Give me thirty per cent. of the proceeds," he said, "and I will show you the place." A third, a blind man led by a boy, came to tell me where there was a "hidden underground palace," and he offered (for a consideration) to show me where it was—the blind leading the avaricious! Then we had the local journalists of Stamboul, eager, anxious, and competitive, who called every morning and rang up every evening for ten days. No sensations being reported after this prolonged time they gave us up as a bad job, and did no more but make polite inquiries, as if we were invalids. For this relief we were thankful.

Our first two or three weeks were thus eventful and disturbed. But with neglect from the journalists and disappointment from the citizens, we at last achieved peace and faced our task with less exhaustion. No archaeologist can ever hope to move except at the most cautious pace, however slow that may be. A shovelful of earth too hastily removed may ruin evidence of the first importance. Excavators are like the detectives of fiction, who collect fluff off the seats of tramcars and dust off boots and keep it bottled and labelled; they are searching all the while for circumstantial evidence because that is all they ever get. The conditions in which an object is found are often more important than the object itself. The nature of soils and their stratification are the touchstones by which they will subsequently test their conclusions and fix their chronologies. If one knows the level at which a few coins are found and the other objects

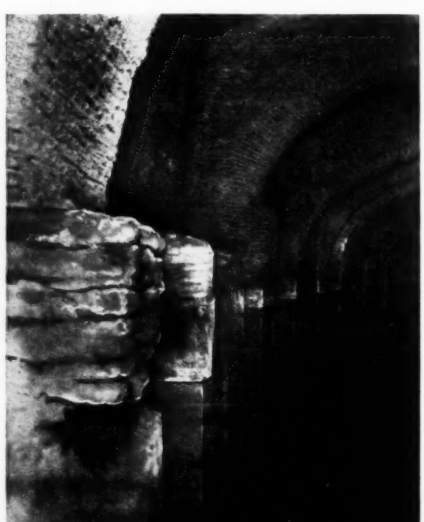


FIG. 3.
THE "SPHENDONE."
This vast substructure of the Hippodrome was originally used for storing apparatus and animals for the Games. Later it was converted into a cistern, and the arches here seen reflected in the water were photographed by flashlight from a raft.

with which they occur, one can date the level and the objects. The same coins merely picked idly from the soil may only be worth a few piastres; but well-authenticated as historical evidence they may necessitate the rewriting of many volumes. Hence in the long run indirectly they have a great intrinsic worth. So it is that the worthless cigarette stump will hang the murderer and save the expense of another crime.

Thus at first we dug the usual trial trenches at various points to establish the depths and so the history of the site. Then by gradual degrees we were able to find the main elements of the structure of the building. Our first task after commencing the preliminary trenches was to examine the substructure of the "Sling" or "Sphendone" (Fig. 3). The curved part was entered and found to consist of twenty-five large chambers, each opening out of a wide corridor that ran round the entire length of the building. Each chamber was about ten metres long and five wide. Five similar rooms were examined along the straight side on the south-east. All alike seem to have served as rooms for storing tackle, keeping animals and personnel for the games and similar purposes. Assuming that these chambers were uniform on each side, there would have been at least seventy-five along each straight side in addition to the twenty-five at the end. So that there was no dearth of accommodation for the purposes of the public games. One can thus get some idea of the magnitude of the spectacles given in the Hippodrome.

Once these underground rooms had been examined it was possible to get some notion of the width of the building. The side walls were therefore sought for and found in order to check this assumption. They were revealed by a deep cutting on the north-west side in an open but confined space adjoining the great military barracks that face the Mosque of Sultan Ahmet. They were cleared to their foundations, and in the process we again tapped the great corridor that runs round the Hippodrome (Fig. 5). It was completely filled with earth from which a very large number of coins were taken. The stratification of these coins gave us in summary the whole history of the building. The earliest were of the time when the Hippodrome was being built (the second and third centuries B.C.), and from the fourth to the eighth or ninth century they were plentiful. But after that they decreased in numbers, and by the time of the Crusaders they were comparatively rare. The inference is clearly that the people who passed along the corridor were less in number as time advanced. The great days of the Games when the crowds passed and repassed along this passage were over by the tenth century. Byzantines were too engrossed in their dangers and their political troubles and the imminent threat of the Moslems to care so much about their games. So too in the "Sling" we found that at some time, perhaps in the eighth century, the repeated invasions and attacks upon Constantinople had compelled the Government to increase the internal water supply in the city by transforming most of the twenty-five chambers and the corridor at the end into a huge cistern. This cistern survives (Fig. 3), and is still a water supply to the straggling slums in the region of the Kuchuk Haghia Sofia Mosque. We were compelled to carry out all our measurements of this part of the building by the aid of rafts and with acetylene flares. Often the raft precipitated us into the dark waters. From

FIG. 4.
MARBLE RELIEF OF THE SECOND CENTURY A.D.
The figure of a sea goddess is holding a trident, with a dolphin in the background. It was discovered during excavation of the Baths of Zeuxippos, where such reliefs probably decorated the walls.

FIG. 5.
SIDE WALLS OF THE HIPPODROME.
The main corridor round the Hippodrome ran between these walls, which were found completely filled with earth. During excavation the many coins unearthed afforded a summary of the building's history.

the side walls we were able to calculate the width of the Hippodrome, which proved to be 117.5 metres exactly.

There remained the length. This we sought for by opening new ground in the open space between St. Sophia and the Mosque of Ahmet (Fig. 1). Here we found almost at once the massive columns of a building which was certainly not the Hippodrome, but which appeared to have joined it by a low bridge. A group of these columns was revealed which were so placed that it became evident that here were once the ancient Baths of Zeuxippos, which, as we are told in our records, adjoined the Hippodrome on the north-east. Soon we found a fine marble relief (Fig. 4), showing a figure of a sea goddess holding a trident, with a dolphin in the background. Other marble fragments were numerous, together with capitals of columns and fragments of columns. Byzantine pottery of great beauty was common—a welcome find, for little or nothing is yet known about the pottery used through all the period of Byzantine history.

A Great Rebellion.

The Baths seemed to have undergone some catastrophe, and to have been repaired later. On the bridge adjoining were five skeletons, three men, one woman, and a child. This, combined with the damage the building had suffered, led us to think that here was tangible evidence of the great rebellion of A.D. 532, the famous "Nika" or "Victory" riots against Justinian which his staunch general Belisarius bloodily suppressed by the slaughter of 30,000 men, women and children. We are told that the rebels held out longest in a building called the "Octagon." Perhaps we have found the Octagon itself; certainly its shape suggests the name. The flat gardens and open spaces that comprise the Hippodrome to-day thus hold much history beneath the surface.

Along the axis of the Hippodrome we examined each of the standing monuments. The first, the so-called "Column of Constantine Porphyrogenitus," provided a curious surprise. It rises some 32 metres above the ground, and is to all intent and purposes a mere obelisk. It is known to have been covered with bronze plates, and its basis was enclosed in bronze except where the stone bearing its dedicatory inscription is left open to view. We dug beneath this tall monument and found a passage large enough to hold a man. On entering this, which I did as soon as it was cleared, I found that I could look up a hole that ran up the vertical axis of the slender column. It communicated with four other holes that opened on to the sides. The basis of the column had, in short, held a fountain with four jets of water playing from each of the four sides. Lead pipes were found still in place.

In the same way the Bronze Serpent Column, which Constantine took from Delphi, and which itself was the war memorial of the Greeks who fought and beat the Persians in 479 B.C., had also been used as a fountain with water spurting from each of the three mouths of the serpent. An old drawing of this column made in 1574 shows it with all its heads intact. (Now all but the one in the Stamboul Museum are lost.) Old legends describe how the Serpent Column in Byzantine days threw jets of milk, water, and wine. This is a fanciful memory of the days when it was used as a fountain. Tradition is justified. We found the water channel that ran beneath it (Fig. 2).

One negative discovery was interesting. All authorities had always said that down the centre of the great Hippodrome ran a wall which divided the course into two parts and that the three existing monuments stood upon it. It is said to have been called the Spina. Actually no such wall had ever existed; we found no trace of it and no indication that it had ever been built. Thus the shovel destroys dogmas. The existence of the Spina had been assumed only because it was thought that in Roman Hippodromes there always was one. Now we know that at Constantinople at any rate it was absent.

Elsewhere we found a fragment of a Turkish wall some ten metres in length, composed almost entirely of marble architectural parts of the Hippodrome. A close examination of these marbles enabled us to reconstruct in general what the superstructure of the building had been. Capitals of columns, marble pilasters, and parts of an elaborate architrave told their story. By careful measurements we are now able to say that the Hippodrome must have looked as follows:—Upon a solid brick and stone foundation which contained the main corridor and the numerous chambers were built up at a gentle angle the marble seats. At the top ran a colonnade round the whole length. Upon the columns was an architrave which was decorated with medallions of bronze nearly two feet in diameter, joined together by a continuous strip of bronze. The total length of the building was 480 metres. More detailed measurements remain to be fixed by later excavations, and we are only at the beginning of our labours.

Amongst our isolated finds was an excellent Hellenic relief of a woman seated on a couch, in exquisite style. It is of the best Parian marble, and was found near the side walls. Besides the numerous Byzantine bowls and cups which were found, we were fortunate enough to get many examples of the finest Turkish

faience of the sixteenth century. Ware of this type is of extreme rarity. It was made largely by the artists who were encouraged by the great Sultan Suliman the Magnificent. It represents the most artistic period of Turkish history, the time when the most beautiful mosques and palaces were built.

We are only at the beginning of an arduous campaign. We have merely solved the first and simplest riddles. Many more remain. Other buildings adjoining the Hippodrome must be examined. One such, a magnificent cistern consisting of eighteen Corinthian columns, formed part of the mass of buildings that lay between the Hippodrome and the great Palace of the Emperors, which awaits the research of other explorers. There is a vast complex of underground buildings in Constantinople which awaits an enterprising archaeologist. The city is an untouched field. Now that, under the Republic, science is given a free hand, there is no end to the discoveries which await the scientists of all lands, and not least those of Turkey, who are taking a profound and learned interest in their own antiquities.

The Mystery of the Porcupine.

By Dan McCowan.
Naturalist at Banff, Alberta.

The habits of what is known as the "mystery animal" of the greenwoods of Canada present many problems, though the author's observations will upset the pretty legend that the porcupine is able to "shoot" its quills.

In North America the rodents or gnawing animals greatly out-number all other mammals. Ground squirrels, prairie dogs, and field mice are found upon the great plains of Canada, beavers and muskrats swim in the many lakes and streams, and high on the rugged mountain side is the home of the marmot and coney. The forests offer covert to tree squirrels, chipmunks, and woodrats. Included in the long list of sharp-toothed beasts which belong to this order are many whose manners are quaint and curious, whose habits and character present to the naturalist problems that may only be solved by close observation.

Outstanding in this large and varied group is the porcupine. Wandering through the coniferous forests at all seasons of the year, moaning and whining to himself, this mystery animal of the wilderness seems to have no aim or purpose in life, and remains aloof from all other forms of wild life native to his habitat. To mankind he is one of Nature's enigmas. His biography might well be illustrated with a series of interrogation marks, several placed at the beginning, many more at the end. The name porcupine means literally, "spiney pig." In mediaeval English the word is spelt "Porkepyn." At a remote period in Canada's history the animal was referred to as "Urson," probably a corruption of the word ursine, meaning bear-like.

CAUGHT UNAWARES.
A photograph of the porcupine taken from life.

A full-grown porcupine has a total length of about three feet, the tail measuring seven or eight inches, and the head four inches; the body girth varies from fifteen to twenty inches. When in good condition an adult specimen weighs about thirty pounds. There is little of beauty or grace in the general appearance of this animal: the body is clumsy and shapeless, the legs short and stubby. In walking, the feet are placed flat upon the ground in like manner to those of the racoon and the bear. To aid the creature in tree climbing, the soles of the feet have been provided with what might best be described as a "knobby tread" surface. The eyes are small and lack lustre, the facial expression being in consequence dull and unattractive. Front teeth that are long and chisel-edged are well adapted to the gnawing habits of the animal, but why these already prominent teeth should be of an orange colour is not readily apparent. A coat of fine silky hair, shading from light yellow to nearly

black, serves to protect the porcupine from winter cold and from summer sun. In appearance, the male and female are alike.

The most striking peculiarity of the porcupine is a highly specialized development of the under-fur into sharp pointed quills. These spines are white with black tips. The body, with the exception of muzzle, legs, and belly, is covered with these quills, which normally lie flat. If the animal be disturbed or molested they are raised by muscular contraction, into an erect and almost impenetrable array of bristling dagger points. The body quills vary in length from one-half inch to over three inches, those on the tail are the shorter but being stouter and more closely set. All are so slightly attached that, should the points touch and enter the skin of a molesting bird or beast, they are immediately freed at the base. Each quill point is so barbed that once driven into the flesh or hide of another animal it can only be extracted by the exercise of considerable force. There are close upon a thousand minute barbs on a quill; these when moistened curl outwards from the main stem in such a way that they are firmly embedded in the flesh of the attacking animal.

"Shooting" Quills.

Tales of the porcupine "shooting" his quills are entirely mythical; nor does the animal curl up into a ball when attacked. His usual method of defence is to guard the unprotected snout by thrusting it into a hole or under a log, to arch his back and to set his feet firmly, meanwhile erecting a myriad of needle-sharp quills. In such position he awaits the enemy's assault. His weapon of offence is the tail, truly an awesome bludgeon. Should the assailant venture too close, this club, with its cruel stinging spikes, swings with amazing speed and with great force. This extremely rapid movement of the tail, together with the fact that many of the quills are dislocated by contact, has probably been responsible for the widespread belief regarding the ability of the porcupine as an archer.

Owing to his very efficient armament, the porcupine is almost free from attack. The cougar, lynx, and grizzly bear will, if driven by hunger, essay to convert "spiney" into a meal, or the wolverine, with his usual indifference to danger, may attempt to combat him. The golden eagle, and even the great horned owl, have been known to attack him, but in every case his enemies have been the chief sufferers. The one carnivorous animal which has successfully overcome the defence of the porcupine is the fisher, a fearless and savage type of weasel found in many parts of Canada. Approaching his victim silently and stealthily, with a dexterous twist of his paw, he turns the porcupine over, then, quick as a flash, sinks his fangs into the unprotected throat or underparts. It is an extraordinary circumstance that the quills of the porcupine, capable of deadly hurt to most creatures, are apparently harmless to the fisher. So long ago as 1829 the eminent naturalist Richardson, who journeyed with Sir John Franklin through North-west Canada, observed and noted the manner in which the fisher kills and eats the porcupine.

Domestic Problems.

Feeding on the inner bark of trees, particularly of spruce and pine, the porcupine is responsible for the destruction of marketable timber. A very small quantity of bark, however, serves for a meal, and so the damage caused by these animals is not very extensive. It is fond of hemlock twigs and esteems lily pads an especial delicacy. In orchard regions it is accused of raiding fruit trees. It frequently does considerable damage to harness and saddle leather, if it happens to be in the vicinity of a camp, as it seems to find nourishment in the salty grease and oil of the leather dressing.

Little is known of the domestic habits of the porcupine. It is known, however, that the young are amazingly large and well-developed at birth. Indeed, a new-born porcupine is many times larger than a new-born grizzly bear. Secure in the possession of a formidable armament, the porcupine moves abroad freely in daytime and may often be seen sunning himself in a lofty tree-top. His favourite sleeping place is within a hollow log or in a rock cavity. With head in, the tail out the slumbering animal is in little danger from surprise attacks. Buoyed up by his hollow quills the porcupine floats easily, and can thus swim for long distances with but little fatigue.

In some regions the porcupine is protected by custom, if not by law, for it is the only food animal of size which can be readily taken by man without the aid of gun or trap. A person lost in the woods can obtain, with little exertion, an emergency ration that is not at all unpalatable. The Cree Indians of Alberta considered porcupine liver to be a great dainty. The economic value of this animal is small. In embroidering various garments the dyed quills are made use of by the Indian tribes.

When all has been said and written, there still remains the problem of Nature's use and place for this strange quill-clad creature.

Domme : A Secret of Old France.

By Moya Jowett.

In a picturesque account of a little-known town of Old France, the author discloses particulars of arrangements that offer readers an unusual holiday. The co-operation of a distinguished archaeologist is available.

DOMME is an old mediaeval hill town perched 500 metres above the Dordogne river, in one of the loveliest parts of France. Domme has been till now a secret to be guarded from charabanc owners and lightning tour conductors; but it is safeguarded by the fact that it contains none of the things so dear to those who like their hotels English and their casino handy. So let me warn all those who want perfect sanitation, subservient waiters with excellent English, and the other appendages of modern civilization, that they will not find them at Domme.

DOMME: THE DELBOS GATE.
Photos by P. Daudrix, Sarlat.

The Dordogne river in its young and turbulent days carved its way through the limestone rock and cut deep twisting gorges. Then it spent the countless centuries of its maturer middle age in thrusting the walls of the gorges further and further back, till now it winds its way through a wide and fertile valley backed by the steep grey cliffs. Sometimes the twist of the river brings it right underneath the cliffs, and Domme is built on one of these isolated walls of limestone. One stands on the edge of the town and sees the river stretching for miles each way far below. On the other side of the town the ground slopes gradually down, and beneath the old walls terrace-gardens go down to Cenac, the little village at the foot of the hill. Ardent spirits can climb up the cliff if they wish, but there is a new gradual motor road that satisfies most people. And Domme is linked to the railway by bus, and the market town, Sarlat, by a prehistoric steam tram. The tram runs quite safely, but the people who live along the roadside borrow the engine if they have any private shunting; and the engine-driver is always willing to oblige them.

Historically Domme is fascinating. Its two roads still go through the old fortified gateways before entering the town—and the broken wall still cuts the town very clearly from the terrace-gardens outside the walls. Domme itself is entirely built inside these walls, which surround it on three sides. The fourth side is a sheer drop to the river. In Roman times there was a camp at the foot of the hill, where Cenac is now. All over this district wherever there are traces of a Roman camp the place name end in "ac." The presumption is that ac is short for *aqua*—water—and means that the Romans found water there and placed their camp accordingly. In mediaeval times the country was covered with dense forests where wild animals and robber bands roamed at will. Therefore the only safe means of travelling and trading was by water down the great rivers of France. That is why every twist and turn of the river had its fort or castle; and these forts which protected the towns that grew up under them, safeguarded the rivers and reaped, in toll on the merchants, a small fortune for the baron.

Before there was any town to Domme, there was a castle, on one end of the plateau. Where the river disappears in the distance one can just see the next one eight miles away. The castle of Domme was, by reason of its position, impregnable. And it is easy to understand that unless the king were a very strong one, these barons did as they wished. They became so powerful that finally the king determined to break them; and by his energetic measures did subdue them. His method at Domme was interesting. He financed the building of a free walled city on the

top of the hill facing the castle, and he built the town of Domme, much as it is to-day, to keep the castle in check. And from that day till the castle was destroyed there was always war between those who held the castle and those who held the town.

The nearest castle up the river is Chateau Montfort. Simon de Montfort, the Frenchman who came to England and founded our parliamentary system to check the king, sowed his wild oats round Domme in no uncertain fashion. We know him as the altruistic baron, but they knew him as one who conducted a particularly fiendish massacre. In those days Domme was held by the religious fanatics known as the Albigenses. The massacre of the Albigenses may have been due to real religious fervour, but it is a coincidence that they were rich, and their extermination was a very profitable business to the pious gentlemen who killed them. Simon de Montfort's uncle headed the crusade, and they besieged and took Domme and exterminated the heretics.

The English territory in France stopped just short of Domme. Naturally he who held Domme could control river traffic. So Domme was taken by the English, and changed hands several times in the next two hundred years. In the guard-room of the Port des Tours, the main gateway, the soldiers on guard carved on the stone to pass the time. The little girl who shows the gateway points out a "dragon." But to English eyes it is curiously identical with the old English leopard or lion with his tail arched over his back, and surrounded by English roses. On the opposite wall is a representation of the fleur-de-lys.

Castle versus Town.

When the English were finally driven from France, Domme became embroiled in the religious wars, and belonged alternately to Hugenots and Catholics until a Hugenot captain took the town by climbing up the face of the cliff and up a well that goes to the top of the hill. He was never dislodged from Domme as long as he lived. For whenever the Catholic nobles began besieging the town, his allies went and attacked their castles, and they had to hurry home to protect them. These skirmishes were always complicated by the fact that the castle and town were never held by the same side, and this sort of civil war persisted till the town finally overthrew the castle and pulled it down.

To-day the descendants of all these Albigenses, English and French, Catholic and Hugenot adventurers live in their old town, which meant so much in feudal days, and means so little to modern industrial France to-day. The industries of the neighbourhood are principally wine making, *pâté de foie gras*, truffles, and walnuts. The people cultivate their terrace-gardens and live on what they grow. They are exceedingly friendly in a dignified way.

Sometimes when we have been walking in the country it has begun to rain and we have taken shelter in some farm or cottage. The floor is of stone, and all the cooking is done over a vast open fire of twigs. The next room contains an enormous feather-bed, and the whole place is as a rule unbelievably dark. But the wife will press home-made wine or strong black coffee upon the traveller, and will only accept a present "for the children" after much pressing. It is a hard life. There are no weekly wages from office or factory, but hard work in the garden or fields or in the millstone quarries.

A Zacchaeus Legend.

Domme is within motoring distance of many places worth visiting. Besides the immediate neighbourhood, with the river to bathe in and the castles to explore, there is a wonderful drive up the valley of the Dordogne to that great place of Catholic pilgrimage Rocamadour. The legend is that Zacchaeus came from Palestine to France when the disciples were persecuted, and climbed the cliff face and lived and died at Rocamadour. Now, if one goes in solemn pilgrimage and climb the 300 steps from the valley to the grotto on one's knees, reciting the appropriate prayers, great indulgences are gained. The town of Rocamadour is built flat against the cliff, and the houses look as if they were built each on the roof of the other.

From there it is an easy drive to Padirac. Padirac is a real experience, and a little weird. It excites the hysterical to laughter and the thoughtful to silence. From the top there is nothing to see but a round hole in the ground, a great pit 100 metres deep. But at the bottom of the pit is another entrance that leads still further down to an underground cavern with a river rushing down the middle of it. There one gets into a boat, and is poled for nearly a kilometre down this astoundingly strange place. At the end it widens into a lake, and then one can walk still further and climb up to see the upper lake and the frozen waterfall that the water has made by flowing down to the river again. The roof is high and domed, and cleverly placed lights intensify the odd and beautiful shapes of the stalactites. The river, with its haunted suggestion of Kubla Khan, flows nearly another kilometre further than it is possible for visitors to go; and then it disappears and is never found again.

Many people have tried to find its outlet in some of the rivers above ground, but no amount of dye put in the water can be traced to any outlet.

I should never have discovered these places, nor yet the charm that comes from going simply into an unspoiled lovely neighbourhood and making it part of oneself, had it not been for two rather wonderful men. Mention of the name of Professor Patrick Geddes in England produces either a blank stare or a gleam of understanding interest. In France, India, Palestine, and particularly in the hearts of young people, he is a great magician who unlocks their imagination, and a wise friend who inspires their work. Professor Geddes visited Domme because his friend Paul Reclus lived there. M. Reclus is the quiet philosopher of Domme. Whatever the troubles, or joys, whether the problem is of business or psychology, all the good folk come to M. Reclus. It was Professor Geddes who saw the value of Domme with its wise man, and its nearness to that other great centre of inspiration Les Eyzies. Many specialists in small branches of research confine their interest to their own restricted area, and refuse to admit that it is feasible to attempt to synthesize these studies into one science. As a result of such a short-sighted policy, one eminent expert on flint implements destroyed half of one of the most beautiful friezes of prehistoric carving, because he had restricted his imagination to flint implements. Professor Geddes' desire, however, is to fit the prehistory of Les Eyzies on to mediaeval and thence to modern conditions in rural France, and so to present a whole picture. It is not necessary for me to describe Les Eyzies, as an excellent article on the caves, with their prehistoric rock paintings, appeared in a former number of *Discovery*.* And M. Peyrony, whose patience has made Les Eyzies the "Capital of Prehistory," is well known as the man who was in charge of the Glozel excavation inquiry.

THE VALLEY OF THE DORDOGNE.
Here viewed from Domme, on the side of the town which makes a sheer drop to the river, the Dordogne winds its way through a wide valley.

LA ROC GAGEAC.
The course of the Dordogne leads it beneath steep grey cliffs, of which the Gageac rock is seen above. At every turn of the river is a mediaeval fort or castle.

We have now "discovered" the Dordogne valley, and Domme with its beauty of red roofs and scenery. It would be easy for any reader to go on his own to Domme and Les Eyzies, and he will be amply repaid. But going alone one will not become one of the people and the place as is possible with M. Reclus. The ordinary guides will show all they know of the caves. But Professor Geddes dreamed of groups of people who would get to know the Dordogne through the kindly personality of M. Reclus, and by a special arrangement with the French Government should have M. Peyrony himself to illuminate with his vivid personality all the story of prehistoric man that lies locked in the rock shelters and caves of Les Eyzies. Tours of this kind do not pay, and it has been left to the enthusiasm of a group of young English people—the Kibbo Kift Kindred—and the generous support of the Wayfarers' Travel Agency to make this dream come true.

Since 1925 it has been possible for a small group of people to go both at Easter and in September, and the people of Les Eyzies and Domme are beginning to like their English caravans. The hotels are extraordinarily cheap, and as I have already mentioned that it is a wine, truffle, and *pâté-de-foie-gras* country, I need not dilate on the cuisine. If the tour is run with every comfort, the cost is sixteen guineas for the fortnight, inclusive of excursions and hotel accommodation, but by going third-class and camping it can be done for nine guineas. Should any readers be interested enough to write to me, care of the editor of *Discovery*, I would gladly let them further into the secret of Domme.

* "Les Eyzies—The Home of the Caveman." By E. N. Fallaize. July, 1926.

Excavations in the Tombs of Dendra.

By Professor Axel Persson.

Edited by A. J. B. Wace, M.A.

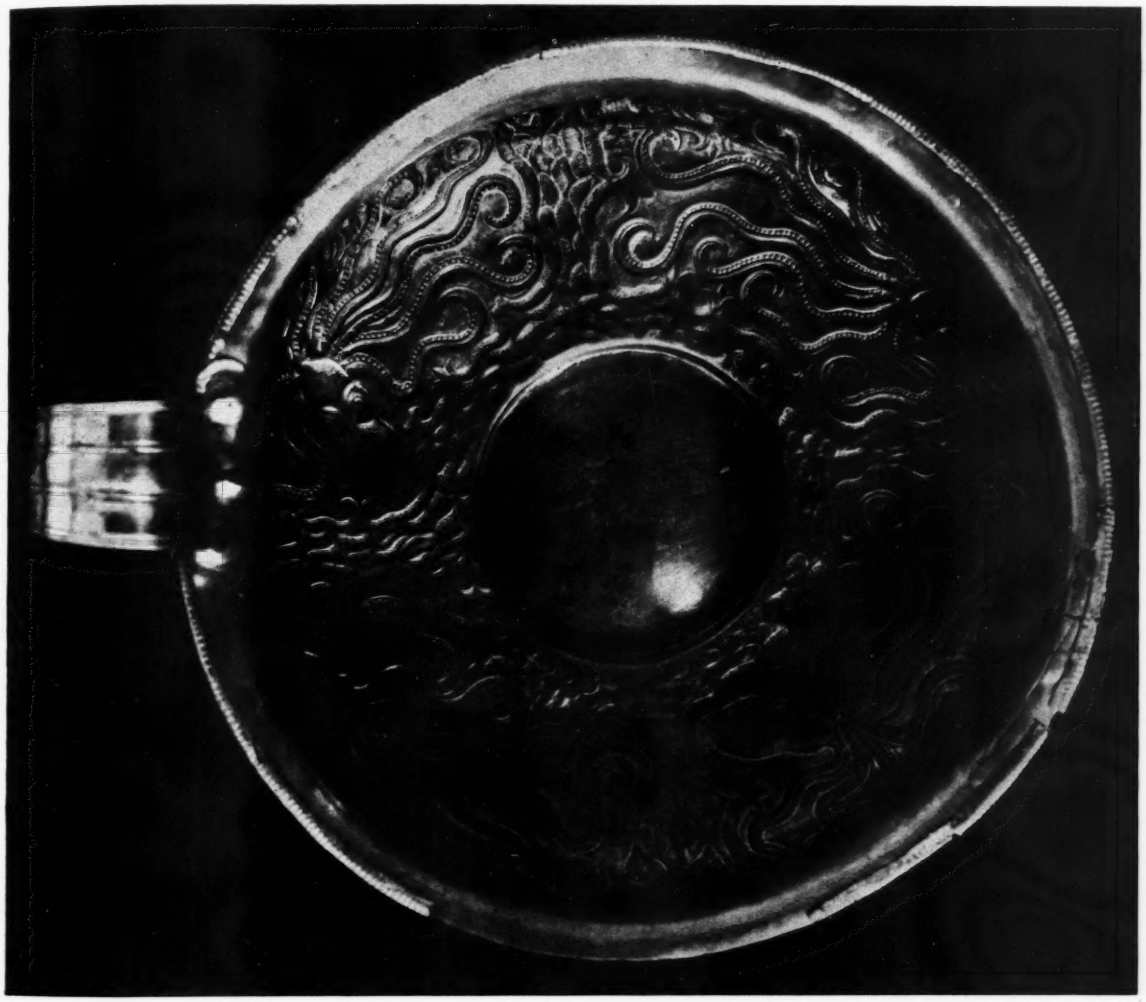
The study is now being completed of the rich finds made in the tombs of Dendra, which a Swedish expedition has excavated during the past two years. The work is in charge of Professor Persson, of Upsala University, whose report is here communicated through Mr. Wace.

THE Swedish Archaeological Expedition to Greece, under the patronage of H.R.H. the Crown Prince of Sweden, who has taken a personal share in its work, has been very successful. From 1922 onwards it excavated at Asine, near Nauplia in Argolis, and obtained valuable results about its history, especially in prehistoric, Bronze Age, times, which, as the preliminary reports already published indicate, will be of great value in working out the earliest history of Greece.

In 1926 the expedition, at the suggestion of Dr. Bertos, Inspector of Antiquities for Argolis, combined with him in excavating a recently discovered beehive tomb at the village of Dendra. This lies at the foot of the lofty citadel of Midea, which ranks after Mycenae and Tiryns as the third of the great prehistoric fortresses of Argolis. As is now well known, though the beehive tomb was in ruins, the rich burials it contained were intact. This was due to the fact that the collapse of the upper part of the tomb at a comparatively early date blocked it with debris, and effectually foiled tomb robbers. Practically the whole ritual of the burial has been determined by the patient care of the excavators. In the floor of the tomb were three pits. One of these, the earliest apparently, contained one skeleton, a "princess," to judge by her golden ornaments. The second pit contained two skeletons, the "king and queen," who seem to have been buried at the same time. They lay with their own appropriate ornaments at the opposite ends of a long, deep pit, with their feet towards each other, while between them lay objects common to both, such as a steatite lamp, and an ostrich egg vase, with applied ornaments of gold, silver, and bronze. By the side of the king lay four swords, one at his right hand and three at his left, and on his body were gold and silver vessels. One of the latter which has now been cleaned and restored proves to be a cup of the same shape as the famous gold cups from Vaphio, and like them is embossed with a scene illustrating the chase of wild bulls. The gold cup which lay on his chest shows a rocky sea floor above which float octopuses. On the surface dolphins are seen diving downwards while argonauts float between them. It is eighteen centimetres in diameter and one of the finest specimens of ancient gold work known. In it were the king's seals, four signets of metal and seal stones. Three of the latter are over three and

THE KING'S SEAL STONES.

These remarkable stones were among the objects found in the "king's" gold cup, and they are here reproduced to the same scale as the illustration opposite. The largest of the seal stones are one and a half inches in diameter, and in their decoration lions are seen attacking bulls. The bull may have been the badge of Crete and the lion that of the mainland.



THE GOLD CUP DISCOVERED IN THE BEEHIVE TOMB.

One of the finest known specimens of ancient gold work, this cup was discovered in the beehive tomb at Dendra. It measures about seven inches in diameter, and on its base octopuses are seen floating above a rocky sea floor. The surface of the cup is also decorated.

a half centimetres in diameter, and on two of them lions are seen pulling down bulls. As the bull is considered by some to be the badge of Crete, and the lion to be that of the mainland, it is suggested that the design may be allusive. At the king's feet lay other objects—knives, swords, spearheads—which are supposed to be the last offerings of his family and his officers, for the ritual of the interment seems to have been thus. When the long pit was ready and the king and queen were laid there in all their state with their more permanent personal property by them, their other more perishable personal belongings were heaped up on a wooden framework placed across a smaller pit alongside. Fire was laid to this to consume the objects, and as those paying their last respects to the royal pair filed by they dropped some object of value as a last tribute into the pit at the king's feet. They probably also poured a libation on the burning pile, because broken pieces of the same vases were found both in the grave pit and in the other pit. This may have been done to quench the fire as was apparently the Homeric custom. The study, cleaning, and repair of all the rich finds from this tomb, which dates from 1350 B.C. and is the only untouched beehive tomb yet found, is not complete, but the full scientific publication is now in active preparation for the Press.

In 1927 search for further tombs was made along the hillside near the beehive tomb. Though no other royal burial came to light, several rock-cut chamber tombs were excavated. The first two may be described as the ordinary good tombs of private persons of about the same period. The third tomb, however, was at once seen to be large and unusual. The entrance passage is twenty metres long and nearly two metres wide, and where it reaches the doorway of the tomb its floor is five and a half metres below the surface. The doorway itself, 2.30 metres high, slightly over a metre wide, and 1.60 metres deep, gave entrance to a tomb chamber 5.10 metres by 4.30 metres in area and 3.15 metres high. The roof, though part of it had fallen away, seems to have been of a saddle type, and is thus related to a series of fine chamber tombs at Mycenae, Argos, and Asine. The doorway had been blocked by a rough stone wall which had collapsed outwards as though someone had forced an entry to the chamber in ancient times. Under the fallen stones was a much decayed skeleton of a woman. This was associated with a few funeral offerings, including some objects of glasspaste once covered with gold leaf. These, if found by the plunderers, had been rejected by them, but the fact that the tomb seems to have been entered in ancient times gave little hope of any important find within. Fortunately, as was afterwards seen, part of the rock roof had fallen in, and so caused a collapse of the door itself, thus facilitating entry to the tomb, but at the same time, since the rock debris covered the floor to a depth of a metre and a half, effectually preventing the plunder of its contents.

DISCOVERY OF BRONZE OBJECTS
The removal of a stone threshold in one of the tombs revealed a large pit filled with bronze objects of the Mycenaean period.

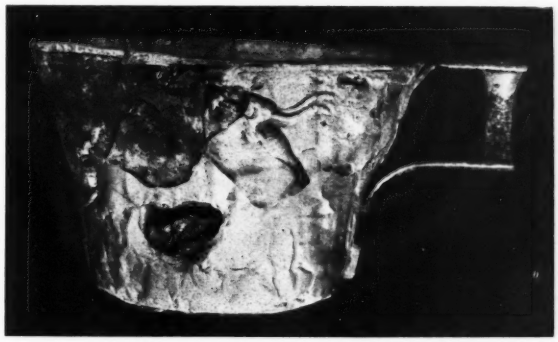
When the stone wall of the doorway was removed there came into sight at the bottom two large stones, making a kind of stone threshold. When they were raised a large pit, 1.60 metres long, .40 metres wide, and .90 metres deep, was found filled to the top with beautifully patinated bronzes, thirty-three in number, large and small. There were six hydriae, seven bowls of various shapes, four tripod cauldrons, five lamps, four mirrors, two knives, two razors, a spearhead, a sword, and a six-pronged fish spear. Several of the objects had exquisitely engraved patterns, flower and shellfish as well as purely linear designs, and the cleaning process will doubtless reveal many interesting details of this as one of the most beautiful bronze finds of the Mycenaean period yet made in Greece. Especially significant is the fact that a large portion of the objects—the sword, the knives, and the mirrors—have retained their original wooden hilts and handles. These have been properly treated to preserve the wood, which when first found was shrivelled and appeared undecorated. Now it has swelled out again, and one of the mirror handles which has some likeness to an ivory one from Mycenae shows two seated women, one holding a mirror the other a branch

OSTRICH EGG VASE.
The holes by which silver decorations were fastened to the shell are clearly seen.

of a tree. As far as Greece is concerned this find of carved wood is unique.

In the debris which covered the floor of the chamber a number of worked fragments of soft limestone were found. These were carefully numbered, collected, and removed. After careful sorting and examination four stone slabs were put together. First comes a sacrificial table two metres long, .85 metres wide, with square sinkings in the corners inside a high rim. Two notches, one on each long side opposite one another, probably had something to do with binding the victim on the stone. The second slab, 1.20 metres long and .80 metres broad, is hewn smooth on one side and on the other has a great number of similar square sinkings. Last come two slabs, 1.25 by .64 metres and .61 by .52 metres, which have incised grooves that recall the Nordic cresset stones. Each has a head-like projection at one end, a feature which suggests some figures from Troy. These two idol-like stones are probably menhirs. Their size, their shape, and above all their cressets, forbid any connexion with ordinary Aegean figures. Such stones have a wide distribution, especially in Scandinavia, Britain, and parts of France and Switzerland, and have been found elsewhere, but not hitherto in Greece. These two stones claim to be considered among the true cresset stones, and point therefore towards the north as does also the menhir shape. The meaning of such stones is much disputed. The purpose of these will be more clearly explained on considering the other finds in the tomb. Two hearths were found in the chamber; one made of small stones covered with plaster is against the inner wall, where two metres from the floor directly above it there are seven deep holes, apparently for fixing metal objects. The other hearth lies on the left of the door, and round both were plentiful traces of charcoal and other signs of fire, while on the wall by the first hearth or altar discolouration from smoke can clearly be seen on the rock.

The tomb was richly furnished with offerings such as three lamps of steatite, one over half a metre high, and four great alabaster vases, three of them Cretan and the fourth Egyptian. There were worked wild boar's tusks from a leather helmet, several gold jewels of filigree work representing shells, hundreds of ornaments of glasspaste with a great variety of patterns and all once covered with thin gold leaf.



EMBOSSED SILVER CUP.

One of the cups found in the king's tomb proved to be of the same shape as the famous gold cups from Vaphio, and like them it is embossed with a scene illustrating the chase of wild bulls.

There was a bronze sword with hundreds of thin white glass beads, which had evidently once been threaded and had formed a kind of beadwork on the hilt. Also there were found thousands of small glass beads, perhaps as many as forty thousand—white, blue, yellow, and brown. These were removed in hundreds as they lay close together and, as they were arranged in a design worked in coloured beads, perhaps once formed a beadwork corslet. This is the first definite evidence of the use of beadwork in Mycenaean ornament and will undoubtedly throw light on previous discoveries. A great deal of pottery was also found, and its evidence would appear to date the tomb soon after 1300 B.C. In the floor two small pits were found, and as that by the west wall was empty it had probably been found by tomb robbers. The other, .40 metres deep and one metre by .30 metres wide, was full of animal

A SACRIFICIAL TABLE.

This was reconstructed from limestone fragments found among the debris on the floor of the tomb chamber. At the corners are square recesses inside a high rim, evidently designed to retain the blood of the victim.

bones, ox, sheep, and goat, among which lay a silver cup, a sacrificial knife, an ivory flower with movable pistil, and an unusually beautiful carnelian sealstone with a design of two recumbent oxen in intaglio.

In spite, however, of the richness of the funeral offerings found in the tomb, there was no sign of any burial and no human bones at all. This extraordinary circumstance, taken in conjunction with the menhir and cresset stones, suggests that the tomb was a cenotaph. That it can have been intended for something other than a tomb is unlikely, for its plan and contents are consistent with those of ordinary tombs. We can only then assume that it is a cenotaph, and that the menhirs were intended to take the place of the body of the dead. They were roughly shaped to supply a material covering for the souls, and it is possible that in the absence of the bodies they underwent the same treatment which the bodies should have received, proper burial rites. If so, the person for whom the tomb or cenotaph was made would have perished at sea or abroad, and his body could not then have been buried by his kin. He would have to receive symbolical burial in order to provide a rest for his soul, and there are several Homeric passages which suggest this. When Telemachus sets out to seek his father Athena bids him if his father is dead raise a mound to him, and make offerings for the dead abundantly as is fitting. Menelaus erected a cenotaph for Agamemnon in Egypt, and Achilles did the same for Patroclus. The thought that lies behind the cenotaph is the calling home of the soul of one who has perished far away, and the preparing of a resting place for it in the empty grave. This would explain the hearth and the sacrifices, for the spirits of the underworld in the Odyssey came to the blood of the sacrifice Odysseus made for them. So when the souls in this manner had been called to the tomb, the offerings customary in the Mycenaean cult of the dead were brought to them so that they would rest there in comfort. Probably this anchoring of the soul in the tomb had a double purpose, that the soul of the dead, some great warrior no doubt, should be at peace and not wander abroad to harm the living, and at the same time should be close at hand to be invoked in time of need.

Sound in Modern Building.

By G. A. Sutherland, M.A.

Principal of Dalton Hall, University of Manchester.
Member of the Privy Council Advisory Committee on Architectural Acoustics.

The first large auditorium in England based completely on acoustic principles has been erected in London. Certain aspects of the science have yet to be investigated, but there is no longer justification for its neglect.

THE world in general, and the British Empire in particular, is full of "audience halls" which are often beautiful to look at but in which a speaker can hardly make himself heard. It used to be said, and even believed, that good hearing was a matter of pure chance, and the appearance of every new building that was more than ordinarily bad was made the occasion of repeating this dictum, and even adding the absurd statement that two *identical* halls could have quite different acoustic properties.

Yet in the middle of the last century the physicist John Tyndall presented a report to a select committee inquiring into the acoustics of the House of Commons, which showed that he was well acquainted with the principles of designing for good hearing. But the question was by him solved only in a general way, and it was about thirty years ago that the first systematic study of the problem was undertaken by Wallace Sabine, an American professor. With a genius for experimenting and great patience, Sabine was able to work out in detail principles of design and correction, and his results, though never published by him in book form, appeared in American architectural and scientific journals. It is a great tribute to Sabine's pioneer work that subsequent experimenting has served rather to confirm his conclusions than to introduce new results.

Yet, although this knowledge has been available for twenty years and has been extensively used in America and Germany, within the last few years legislative chambers and other halls have been constructed in every part of the British Empire, almost all of them in defiance of Sabine's principles, and the year 1927 has seen the erection of the first large auditorium in England whose design has been based almost completely on acoustic principles—the new Friends' Meeting House in the Euston Road, London, which seats fourteen hundred people and in which speaking may be from any part of the room.

When we speak of good hearing we mean, first,

uniform and *adequate loudness*; second, *distinctness*; and third, *accurate rendering*. In other words, the sound must initially be loud enough everywhere in the room, there must not be much overlapping between successive sounds, and the different simultaneous components of which every sound is made up must preserve their proper relative intensities.

Loudness.

Uniform loudness is associated in practice with the absence of curved walls. That this is so might be inferred from the fact that all "whispering galleries" owe their peculiar properties to curved walls or ceilings, and if there are special concentrations of sound in some places there are always corresponding deficiencies elsewhere. It is generally supposed that in the gallery at St. Paul's the sound is heard equally at any point round the wall, but if one ear be stopped it will be found that as the other ear is moved round the wall it will find loud and deaf points alternately. So for uniform loudness curved surfaces are generally best avoided. They can sometimes be used without detriment, but then their position and curvature have to be carefully selected.

Adequate loudness depends on a number of things. It has been said that the ear is so sensitive that, were there no disturbing effects, a speaker as far off as America could be heard in England. And the necessary intensity for hearing in any room is closely bound up with the distinctness attainable. In fact, owing to the increased distinctness attained by whispering, Sir Richard Paget has in certain bad halls been able to make himself better heard when he whispered than when he spoke in his ordinary voice. But as a practical guide under the conditions of rustling, etc., usually present in a large hall, we may take the 50 feet rule, *viz.*—that everyone within 50 feet of the speaker should be able to hear sufficiently well by means of the direct sound alone, and that those further away will require the assistance of sound reflected from some suitably placed surface. If the room is correctly designed the natural surfaces, walls, and ceiling, can be made use of for this purpose. Sometimes it may be necessary to introduce special splays.

Much the most important condition is that for *distinctness*, and the value of Sabine's work lies in his having been able to express this condition numerically and showing, also numerically, how it might be attained. Since indistinctness is due to the overlapping of successive sounds, it is clear that to produce distinctness the sound of any one syllable should die away rapidly once it has passed over the audience. This was accomplished automatically in the classic theatre, for there the sound simply escaped into the open. But in the modern auditorium it is thrown back by ceiling and walls and will produce either the distinct following sound we call *echo* or the confused prolongation of the sound known as *reverberation*. Excessive reverberation is much the most common defect in modern audience halls.

By a survey of different good halls in America and Europe, Sabine was able to show that satisfactory acoustics were associated in practice with a particular reverberation period, *i.e.*, the time taken for a sound of given intensity to die away to inaudibility. More extensive surveys on similar lines have shown that the allowable period varies with the size of room. It is also clear that since in music some blending of successive notes is desirable, the appropriate periods for speech and music will differ slightly. The desirable periods are given by formulae, and vary from 0.9 for speech and 1.1 seconds for music in the case of a room whose volume is 8,000 cubic feet to 2.0 and 2.5 seconds respectively where the volume is 1,000,000 cubic feet.

Sound Absorbers.

It now remains to consider how any given period may be attained. As we have seen, the quicker the sound can be got rid of, the shorter the period. Since the method of the classic theatre, the open-air method, is not available to us, we have to introduce into the rooms special materials to absorb the sound. The values of different materials and objects for this purpose may be gathered from the following table, which shows the fractions of sound falling on them absorbed by surfaces of different materials:—

Open window	1.00
Hard plaster	.02
Soft plaster	.034
Wood panelling	.06 to .10
Special acoustic plaster	.25
Heavy curtains in folds	.5 to 1.0
Heavy pile carpets	.3

Thus 100 sq. ft. of hard plaster will be equivalent to only 2 sq. ft. of open window, whereas 100 sq. ft. of suitable carpet may be as valuable as 30 sq. ft. of open window. For isolated units the following figures hold:—

		Sq. ft. of open window.
Hardwood chairs	each	.1
Upholstered seats	,,	1 to 3, depending on material and lining.
Persons	,,	4·7

i.e., an audience of 100 persons provides 470 units of absorption. The audience is much the most important absorbing factor in any auditorium, and this explains

why it is usually so much easier to be heard in a full than in an empty room. It will also be clear that if a room is to be used for a varying audience the acoustical condition cannot be the same at all times, but variations in the number present can be made to have least effect upon the condition by making the vacant places as absorbent as possible. In practice this means having well-upholstered seats and, for this purpose, the seats it is most important to cushion are those least likely to be occupied.

A very simple relation, $t = \frac{V}{20\,A}$ holds between the volume of the room (V cubic feet), the time of decay to inaudibility of a sound of one million times the minimum audible intensity for the pitch in question (t seconds) and the absorbing power of the room, (A sq. feet of open window).

A is simply found by multiplying the area in sq. feet of every surface in the room by the appropriate fraction taken from the table and adding in the contribution of audience, etc. Then, if the value of t as calculated from the formula is too high, more absorbing units must be introduced until it is brought down to the required value. An example will make this clear.

Correcting a Music Room.

For a music room of volume 64,000 cubic feet the appropriate time of reverberation would be 1.4 seconds. Substituting these values in the formula $t = \frac{V}{20\,A}$ we find that A works out at 2,286 units.

The absorbing factors in the room are

Plaster and glass,	78,500 sq. ft. at	.025	187
Wood	900 sq. ft. at	.03	27
Seats	400 sq. ft. at	.1	40
Audience	400 at	4.6	1824
			2078

This is short of the desirable number by 208 units, which could be made up by the substitution of special acoustic plaster for part of the ordinary plaster, or by the provision of a suitable area of heavy carpet in the gangways or of curtains on the walls.

The ear can distinguish as separate sounds which reach it at intervals greater than one-fifteenth of a second, in which time sound can travel 75 feet. This is the phenomenon known as echo, and in practice usually occurs with first or second reflections from distant surfaces. Such distant surfaces may be the ceiling if it is too high (over 40 feet) and the back wall. Such long reflected paths, tending to produce echo, may be got rid of by breaking up the surface producing them, usually the back wall, or lining it with absorbent material, or by raising the seats in tiers so that the sound which might produce an echo from the back wall never reaches it. The worst type of echo occurs with curved surfaces in a large room, for these produce sound foci, and it may therefore happen that the reflected sound reaching a particular point is more intense than the direct one. In a hall at the University of Illinois a speaker could hear ten such echoes of his own voice. When attempting to get rid of an echo by breaking up a surface, it is necessary to remember that whereas slight roughening is sufficient to make a surface a bad reflector of light, where the waves are about one ten-thousandth of an inch long, deep and wide coffering will be necessary to produce a similar effect on sound waves, whose length for musical sounds varies from about 3 ft. to 3 ins.

When we come to consider the third of our desiderata, *accurate rendering*, a complication is introduced by the fact that the materials in an auditorium absorb notes of different pitches to different degrees. Inasmuch as every musical sound is composed of a fundamental tone which gives it its pitch and a number of overtones of different pitches, the relative intensities of which give the note its quality, it is clear that the quality of the sound as heard will depend not only on the instrument emitting it, but also on the room in which it is played. With an eight foot organ pipe for which the overtones were pronounced in an empty room, Sabine found that the introduction of felt reduced the ratio of the first overtone to the fundamental by 40 per cent., that of the third overtone by 50 per cent., and that of the fourth by 60 per cent. With a six inch pipe, on the other hand, the effect was to accentuate the overtones, but all notes below the six inch fundamental were purified. The effect of an audience was quite different.

The musical effect will thus be injured or improved according to circumstances. The mixture stop in an organ is designed to be rich in overtones, the night horn stop to be specially pure; and it may happen that the room in which they are sounded will completely alter the intended effects. To determine the balance must lie with musicians, and the judgment of musical authorities should be gathered and made available. But so far as the writer is aware, this has not yet been attempted at all systematically.

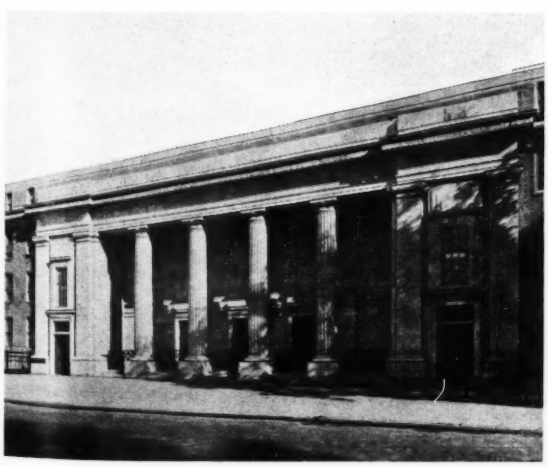
The type of room in which demands are most exacting is that in which speaking may be undertaken from any part. Usually this is a debating chamber, and the audience, besides being variable, is probably small for the size of the room, because of the necessity of providing easy access. Loudness and distinctness, always important, are here particularly so since the

speaker has some of his audience behind him, and there will probably be an exceptional amount of disturbance from whispering and from the noise made by members entering or leaving during a debate.

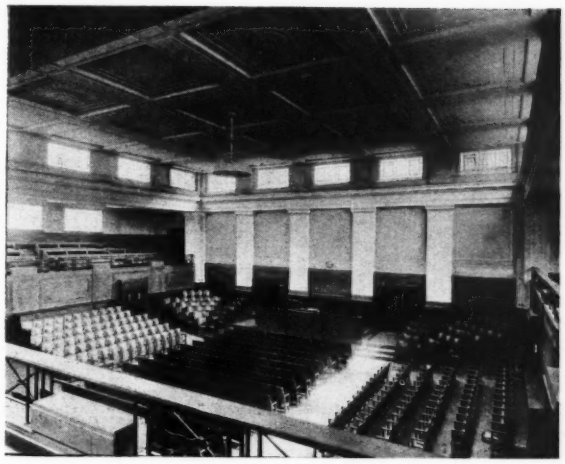
The direct sound should have an uninterrupted passage from any speaker to any member of the audience. This will mean raising seats in tiers and avoiding overhanging galleries. The ceiling is the best surface to use as a reflector, since it acts equally well in whatever direction the speaker is facing. It should therefore be made hard and reasonably flat, and to avoid echo must not be higher than 40 feet above the floor. In the new Friends' Meeting House referred to earlier these conditions are fulfilled. Usually when there are galleries it is well to have them under the main ceiling rather than under separate lower ceilings, but this is often impossible because of other considerations, and was so in this particular case. There is a good deal to be said for dispensing with galleries altogether and having the seats in continuous tiers. This is done with great success, I understand, in a Cairo Theatre, though the semi-circular plan of the seating there adopted is unsuitable for a debating chamber where speaking is not confined to a rostrum position.

As a debating chamber will not be used for music, a specially low reverberation period can be suitably arranged, and heavy carpets on gangways, in addition to the upholstered seats already mentioned, will not only assist this but also lessen the disturbance caused by entering and leaving. The Press may suitably be provided with seats in a well in the floor of the chamber and should have a separate exit staircase.

In conclusion, something may be said about popular ideas of the necessary conditions for good, and suitable remedies for bad acoustics. The most frequently



EXTERIOR OF THE NEW MEETING HOUSE



ACOUSTICS IN PRACTICE.

The auditorium of the new Friends' Meeting House, the first example in England of real acoustic design embodying noteworthy acoustic properties.

laid down condition for good acoustics is that the dimensions of a room should be accurately in the ratio 2 : 3 : 5. Some writers say 1 : 1 : 2 or 2 : 3 : 4. The exact origin of these ideas is not known, but from considerations advanced earlier in the article it will be seen that they are quite irrelevant. The shape of a room is within certain limits important, but there is no importance in conforming rigidly to this whole number standard.

The most popular remedies for bad acoustics are the stretching of wires in the room and the provision of resonant vases. What functions these were supposed to perform, and how they did so, are mysteries. Thin wires have as much effect on sound waves of length 50 to 5,000 times their diameter as a fishing line has on the waves of the sea. The idea to use vases probably arose because such vases have been found in classic theatres. The argument apparently was, " The classic theatre had good acoustics and the classic theatre had vases. Let us too have vases in order that we may have good acoustics." Apart from the fact that as arranged they could not possibly have accomplished this object, we have seen that the characteristic defect of the modern auditorium is the direct opposite to that of the classic theatre.

Sufficient has been said to show that designing an audience hall for good acoustics is now no matter of chance, but, indeed, that a room acoustically bad is quite inexcusable. We demand that a house shall be not only a beautiful place to look at, but also a beautiful place to live in, and we may rightly demand that an audience hall should not only be housed in a noble building, but should also be a beautiful room for hearing and speaking.

Searching for Island Galaxies.

By A. Vibert Douglas, M.Sc.

McGill University, Montreal.

The following is a first-hand account of a subject that is at present largely engaging the attention of American astronomers. The author suggests that the systems usually termed island "universes" are more adequately described in the title above, and he explains clearly the relation of the Einstein Theory.

THE knowledge that the heavens contain bodies that are neither planets nor stars is age-old, for the keen eyes of the star-gazers of civilizations long since gone did not fail to detect such objects as the nebulosity in the constellation of Orion and the small, hazy patch in Andromeda. But the significance of these objects remained a mystery for many centuries.

With the invention of the refracting telescope by Galileo about 1600, many of the apparently nebulous regions in the Milky Way were found to be resolvable into separate stars. These are so closely strewn in the sky that to the unaided eye their light is completely merged and blended. Towards the end of the seventeenth century, the second great type of telescope was devised by Sir Isaac Newton, namely, the reflecting telescope in which the starlight is brought to a focus not by a lens but by a mirror. About one hundred and fifty years later, when the small pioneer telescopes of Galileo and Newton had given place to large and powerful instruments, Lord Rosse discovered that a certain nebulous region in the constellation Canes Venatici when viewed through his great telescope was a cluster of many stars, and not merely a random, haphazard cluster, but distinctly grouped in the configuration of a spiral (Fig. 5). Thereafter the search for and discovery of other spiral nebulae became one of the most fruitful tasks of the astronomer. From that time to the present, as a result of ever-increasingly powerful instruments together with the introduction of photographic methods, many hundreds of spiral nebulae have been found.

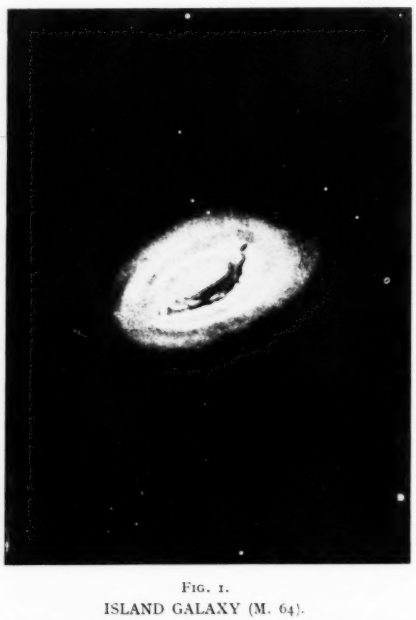


FIG. 1.
ISLAND GALAXY (M. 64).
An early type spiral nebula in the constellation Coma Berenices. This and the other photographs reproduced with this article were taken at Mt. Wilson Observatory, U.S.A.

Speculation was at once begun. Could it be that all the nebulae were in reality close assemblages of stars requiring only yet more powerful telescopes to show each star separately?

Sir Wm. Huggins gave the decisive negative answer to this question—some of the nebulae are great clusters of stars, but there are others truly named nebulae, for they are masses of glowing gas having the type of spectrum typical of gas so hot that the atoms are radiating their characteristic quanta of energy.

Such is the nature of the Great Nebula in Orion, and of many other nebulae where vast regions of space are sparsely filled with gaseous matter. Where these gases are sufficiently hot, they radiate the distinctive wave-lengths of light associated with the atoms and molecules of which they are composed. Thus the spectroscopist identifies in these nebular spectra the unmistakable radiations of hydrogen and helium, often also nitrogen and carbon, and in addition to these he finds intense radiations which as yet have not been reproduced in the laboratory. They are probably due to some of the simplest gases radiating under conditions very difficult to produce in a laboratory. These elusive molecules are called "nebulium," and happy will be the investigator who succeeds in solving the mystery of their true nature.*

The gaseous nebulae are not all sufficiently hot to radiate; some of them glow only because of the proximity of very bright hot stars; others are so

* An editorial reference to the problem will be found at the conclusion of this article, on page 90.

cool that they absorb all the starlight that falls on them, thus forming great black patches in the sky. A famous dark nebula in the region of the Southern Cross is known as the "coalsack." A great American observer, the late Professor Barnard, has made a systematic study of these opaque clouds, of which he listed over one hundred and eighty, varying from very small patches with sharp outlines to the long irregular "dark lanes" so striking a feature of the constellation of Ophiuchus.

We know, then, that of the celestial objects called nebulae, some are vast clouds of gas occupying regions of space compared with which our solar system is absolutely insignificant, while other nebulae, in particular the spiral nebulae, are clusters of stars.

For a long time no one had any conception of the immensity of spiral nebulae. They were thought of as comparatively small aggregations of stars within the great assemblage of stars surrounding our sun in all directions. The authors of the Planetesimal Theory drew an analogy between the arms of a spiral nebula and the arms of gaseous matter which they assumed to have been drawn out from the surface layers of our sun by the tidal forces produced by a passing star, these disrupted arms giving rise to the several condensations of matter which eventually became the planets of the solar system. Gradually, however, it became apparent that a spiral nebula was not to be compared with the solar system, but rather with the whole galaxy of stars—our sun and the thousand million other suns which stud the heavens all around us.

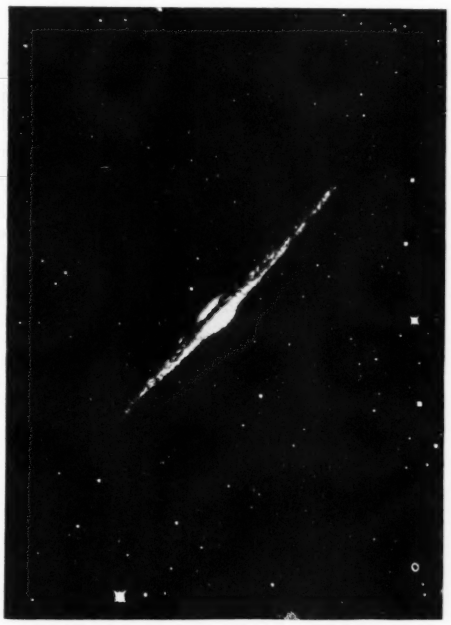


FIG. 2.
ISLAND GALAXY (H.V. 24).
Edge-on view of a spiral nebula in the constellation Coma Berenices. Five hours exposure. Foreground stars are in our Galaxy and the brighter ones are distorted by over-exposure.

There are known to be many thousand spiral nebulae, and if each be comparable in size to our whole stellar galaxy, it is obvious that they are not within it. They are, in fact, *island galaxies*. The term is here used to denote exactly the same thing as the term Island Universes which has become so common an expression in American astronomical writing. Since "Universe" is defined as "all that exists, the creation and the Creator," its use in the plural seems unfortunate, especially as the word Galaxy is quite adequate. Dignifying our stellar system by the name *the* Galaxy—not merely because it is the system to which our sun belongs, but for the more logical reason that as yet no other aggregation of stars is known to be quite as large—it then becomes natural to divide all nebulae into two main classes, termed respectively the *galactic* and the *extra-galactic* nebulae.

Our galaxy is a gigantic aggregation of stars and gaseous nebulae. It comprises all the stars visible to the naked eye and the many thousands more revealed by the telescope when used visually. These numbers are multiplied many-fold by the use of photography when stars so faint or so remote as to be invisible leave the impress of their images upon the sensitive plate after many hours of exposure. The study of these photographs, counting the numbers of the stars of different magnitude or brightness, and comparing the numbers in different parts of the sky, has shown that it is possible to make an estimate of their number and a representation of their distribution in space.

Even with the unaided eye it is evident that the distribution of stars is not spherically symmetrical. All along a great circle in the heavens the stars are more numerous than elsewhere, and this encircling band is called the Milky Way. The photographic plates reveal the same concentration, and so the Milky Way is called the galactic plane, while the directions at right angles to this plane, where the stars are less numerous and on the average less distant, are termed the galactic poles. Our sun happens to be situated not far from the centre of this great lens-shaped cluster of stars. The dimensions of the galaxy are so vast as to be best appreciated when expressed in light-years, the unit so frequently employed by astronomers, equivalent to nearly six billion miles. Our galaxy is approximately 100,000 light-years across the galactic plane, and about one-fifth as much measured towards the galactic poles.

In this vast region, at great distances one from another, there are thirty thousand million stars,

FIG. 3.

THE GREAT NEBULA IN ANDROMEDA (M. 31).

One of the least distant of the Island Galaxies, just visible to the naked eye; it is made up of some thousand million stars and much gaseous matter, and is the best known of these bodies.

according to the most recent calculations reported by Dr. C. G. Abbot of the Smithsonian Institution, Washington. As these are by no means equi-spaced, there are concentrations of stars here and there which, seen from another part of the galaxy, produce such beautiful effects as the "star-clouds" in Sagittarius or the "globular clusters" in Hercules and other parts of the sky. Within the galaxy, too, filling great regions of space around and between some of the stars, are the gaseous nebulae both dark and bright.

Returning now to the extra-galactic nebulae—the great gaseous objects and star clusters like islands in a three-dimensional ocean of space beyond the Milky Way—we are indebted to Dr. E. P. Hubble of Mt. Wilson Observatory for much new knowledge concerning them. In a recently published paper* he has given the results of a careful study of four hundred such nebulae. Some of the extra-galactic nebulae show no regularity of shape or structure. These form a sub-class by themselves, and to this class belong the Magellanic Clouds, great irregular star-clouds visible from the southern hemisphere like detached portions of the Milky Way, though actually as far away again. Far more numerous than the irregular nebulae are those having a definite shape or structure, the ellipsoidal and the spiral nebulae. The spectra of the former are so similar to the solar spectrum that there is no room for doubt that they are clusters of stars, even though the individual stars cannot be photographed. Possibly the stars are being gradually condensed out of the gases of which the nebulae were composed, and the residual gases act as envelopes rendering the star images indistinct.

Some of the nebulae are apparently at a transition stage between ellipsoidal and spiral, while yet others display well-developed spiral arms. The evidence seems strongly to point towards an evolutionary process as a glance at the illustrations will make clear—the gradual unwinding, the appearance of stars and star streams, the whole vast process of the development of island galaxies.

With this idea of progressive development in mind, the spiral nebulae are said to be of *early*, *intermediate* or *late* type, according as they present the appearance

FIG. 4.

SPIRAL NEBULA (M. 101).

A very beautiful Island Galaxy in the constellation Ursa Major. Four hours exposure.

* "Extra-Galactic Nebulae." E. P. Hubble. *Astrophysical Journal*, December, 1926.

of the uncondensed nebula in Fig. 1, or intermediate forms between that and the well-developed, far-flung, stellar arms so clearly shown in Figs. 4 and 5.

The distances of some of the spirals have been determined in a very interesting way. These spirals contain stars, known as Cepheid Variables, whose light is not steady but fluctuates with perfect regularity, falling slowly from maximum to minimum and then rising rapidly to maximum. The light cycles usually have periods of a few hours or a few days. When studying similar stars whose true brightness was known, Miss Leavitt of Harvard Observatory discovered the fact that the longer the period of light variation the greater the intrinsic luminosity of the star. This relation was well established for the less distant stars, and it seemed so logical to expect stars with identical characteristics to obey the same law whether near or far, that it has been applied to stars in these remote galaxies. From a series of photographs, the period of light variation is found, then the established relation gives the true luminosity, and this, together with the apparent brightness on the photographs, gives the necessary data for calculating the distance.

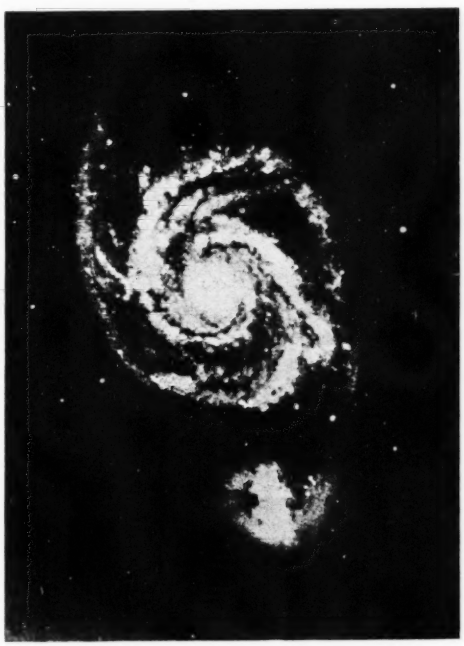


FIG. 5.
THE WHIRLPOOL NEBULA (N.G.C. 5194-5).
This spectacular spiral in the constellation Canes Venatici was first carefully observed by Lord Rosse and seen to be not merely a mass of glowing gas, but an aggregation of many stars.

It was by this method that Hubble determined the distance of the Great Nebula in Andromeda (Fig. 3) to be more than nine hundred thousand light-years. Another very large, bright spiral in the constellation of Triangulum was found by similar means to be at about the same distance. It is believed, however, that the thousands of fainter spirals are very much more distant. In Figs. 1 and 2 are shown two of the spirals in the region of the heavens designated by the constellation name Coma Berenices. Here, and in the adjacent region of Virgo, spiral nebulae are richly strewn on photographic plates of long exposure, and both Hubble and Shapley have estimated for some of these no less a distance than a hundred million light-years.

In spite of these tremendous distances much can be learned about the island galaxies, though, of course, the further away a galaxy is, the less up to date will be the news which the light brings. Thus, in the case of the Andromeda Nebula, approximately one million light-years distant, the rays of light which produced the image on the negative of Fig. 3 had been travelling through space for a million years, and consequently the picture we see is not Andromeda Nebula as it is to-day, but as it was one million years ago.

Just what it is like now we can only conjecture—probably not so very different from the picture, for one million years is less in the life of a star than one second of time in the average life of a man.

The radial velocities of the brighter nebulae can be determined by means of the spectroscope, and show that they are moving through space with great velocities. The Andromeda Nebula is approaching our galaxy with a velocity of 300 kilometres per second. Most of the spirals, however, are receding at speeds averaging 600 kilometres per second.

There are two ways of endeavouring to find out the total mass of a galaxy, and when two quite independent methods lead to results which are in good agreement the astronomer feels considerable confidence in the reliability of his calculations. The first method is based upon a speculation regarding the ratio of luminous to non-luminous matter in a galaxy and the theory that the luminosity is determined by the mass. When the absolute luminosity of a galaxy is known, its total mass can therefore be calculated. This method has been used by Opik, and gives for the Andromeda Nebula a mass nearly two thousand million times the mass of an average star like our sun. The second method depends upon the spectroscopic determination of the line of sight velocity of opposite edges of the nebula. If one side be found to be approaching and the other side receding, the only logical conclusion is that the whole nebula

is rotating. Now a rotating mass will fly asunder by centrifugal force unless some equal and opposite force hold its members together. If gravitation, acting towards the centre of the nebula, provide this balancing force, it is possible to calculate the total mass necessary to give rise to the restraining force required. The period of rotation of the Andromeda galaxy was found to be 17,000,000 years. From this its mass was calculated, giving just over three thousand million suns. The agreement with Opik's result is satisfactory.

Our picture of this best known island galaxy can be briefly summed up in a few words: A thousand million stars—like those in our own galaxy, some larger and some smaller than our sun—and much uncondensed gas, all forming the giant spiral nebula travelling through space at least 300 kilometres per second, and as it travels, slowing expanding and unwinding its spiral arms, while as a whole it is turning round with solemn, majestic deliberation.

The Einstein Universe.

Men of science throughout all the ages have been obsessed with the idea that there is order in the Universe.* When the great wave of agnosticism passed over Europe, threatening to sweep the thoughts of men from all moorings, this fundamental tenet of scientific faith was the sheet anchor which saved mankind. So deeply implanted is this belief in natural law and order, that when some facts of astronomy and physics appeared to be incompatible with the current conception of the Universe, based as it is on the stately geometry of Euclid and the Newtonian mechanics, men of science were willing to consider throwing over the old conception and adopting a new conception suggested by Einstein. This willingness is the more remarkable when it is remembered that, to the non-mathematical mind, the four-dimensional spacetime universe of Einstein seems mysterious, fantastic, and unreal. Yet there is already considerable evidence in its favour, and so, generalizing from his detailed study of 400 galaxies, Hubble proceeds to evaluate the radius, volume, and mass of the Einstein Universe.

He calculates first the average density of space. If the matter forming all the stars and gaseous nebulae in our galaxy and in the 400 other galaxies studied by him were to be spread evenly throughout the space occupied by these galaxies, there would be a density of matter equivalent to one atom of hydrogen in every 300 cubic feet. He then evaluates the radius of curvature of spacetime, which, according to Einstein, depends only upon this average density and two constants, the velocity of light and the gravitational constant. This radius comes out to be five thousand billion astronomical units (5×10^{15} times the sun-earth distance). This value is a thousand times greater than that calculated by Silberstein from other relations and other data available three years ago.† Here in reality, as always metaphorically, the horizon recedes as knowledge increases.

What then is the total amount of matter distributed as stars and as nebulae, in clusters and in galaxies, throughout this vast yet finite Universe? To express these figures in words is far too cumbersome, and so we set them forth in the elegant shorthand used always by the physicist and the astronomer—If M be the total mass of matter in the Einstein Universe, then

$$M = 1.8 \times 10^{57} \text{ gms.}$$
$$= 9.0 \times 10^{22} \text{ suns}$$
$$= 3.5 \times 10^{15} \text{ normal galaxies.}$$

In other words, there are about a thousand octillion (10^{51}) tons of matter, and were this to consist only of hydrogen there would be 10^{81} atoms.

How much real value these stupendous figures have, it is impossible to say. Firstly, they involve the Einstein conception of the Universe, not yet indisputably established. Secondly, they are conclusions regarding a Universe not one ten-millionth of whose volume can be explored by even the giant telescope at Mt. Wilson Observatory. If the distance of a galaxy exceed only one six-hundredth of the radius of curvature above mentioned, no telescope yet constructed can detect it. But a man will judge the world of humanity, their habits and characteristics, their comings and goings, by his knowledge of a few score individuals and his passing glimpses of a few thousand, and his conclusions will not be entirely valueless. So, too, the astronomer, with reliable knowledge of hundreds of stars and many nebulae, and glimpses of thousands yet more distant, will not refrain from speculation regarding the vast regions as yet beyond his ken—the ocean of space-time studded with a thousand billion glorious Island Galaxies.

REFERENCE.—The latest explanation advanced for "nebulium"—a problem to which the author refers on page 86—was dealt with last month in *Discovery* ("Among the Stars"). When passing through "metastable" states, atoms do not radiate light under ordinary conditions, but Dr. Bowen suggests that at the extraordinarily low nebular densities, collisions are extremely rare, and the metastable atoms get a chance for radiating light before their condition is changed by the collision.—ED.

* An interesting treatment of this subject may be found in "Science and the Modern World," by Dr. A. N. Whitehead.

† See "Measuring the Universe," *Discovery*, September, 1924.

People of the Great Plains.

By J. E. Pryde-Hughes, F.R.A.I.

Interesting sidelights on peasant life in Hungary to-day were obtained by the author during travels among peoples whose local traditions date back many centuries. The war has altered political boundaries, but the main racial factors remain unchanged.

BEFORE the war, when Hungary was a partner (if an unwilling one) of Austria, the frontiers of the country stretched along the Carpathians in the north, and the Adriatic in the south, and along the old Rumanian frontier, enclosing Transylvania, in the east, and Austria on the west. It was a remarkable geographical unit, the limits of the land being natural boundaries, and it enclosed not only the predominant race, the Magyars, but large and small pockets of other races, such as the Wurtemburgers, Rumanians, Slovaks, etc., and small nations like the Croats. These all preserved their customs and languages, and their religions, for Hungary—a definitely Roman Catholic country throughout—has always been tolerant in regard to religion.

Early Settlers.

Mingled with the people are descendants of the settlers encouraged by earlier monarchs, or left behind as the waves of Middle-Age invasions receded—Franks and Slavs, Walloon, Italians, a little Turkish blood in certain parts, and in the west the Kumans, pagans who settled in large numbers after the Mongol invasions, at a time when Hungary stood as the stalwart of western culture and religion on its eastern frontiers.

To-day Hungary, a free nation, is very much reduced, and her frontiers are economically and geographically unsound. In my trampings recently, I had not far to go before factors presented themselves to prove this. However, as nations go in Europe in our times, the present frontiers enclose a comparatively pure race, predominantly Magyar.

It is well over a thousand years ago that the Magyars poured over the Carpathians and into the Great Hungarian plain. Here they fought and disposed of the inhabitants, a mixed race of Bulgar and Slav, Hun and Avar, and finding an elementary civilization, finally settled down to develop it. Prior to the Magyar invasion there had been various occupations of the land; following the Bronze period we learn of Germanic Marconians and Quadans in the North-western Highlands, Gaeto-Dacians, whose origins we do not know, and who were absorbed by the Romans, in the Transylvanian basin, then Goths, Vandals, and Gepidae and the mixed Sarmatians.

It was in the fifth century of the Christian era that the first of the Central Asiatics on their westward migration, the Huns, under their great chieftain Attila, swarmed over Hungary, and from an encampment between the rivers Tisza and Danube prepared for the "conquest of the world." How far Attila progressed we know from the history of our neighbours. But Attila's dream was unaccomplished when he died, and the Huns, losing heart, for the most part returned to Asia. Their westerly path was followed some years later by a kindred folk, the Avars (who have left many traces of their occupation in the soil of the Great Plain). They enjoyed possession of the land for about two hundred years, during which time they were attacked by Franks on the west, who took Esztergom, the old *Salva Mansio* of the Romans, and renamed it Osterringun. Esztergom is now the home of the Primate of Hungary, and centre of the Roman Catholic religion of the country. Southern and western Slavs also filtered in and a peaceful period of development reigned till the arrival of the Magyars.

A Disputed Origin.

The Asiatic origin of the Magyars is still a subject of argument. It would seem that they belong to the Ugrian peoples settled in the broad territory between the rivers Ob and Irtish in Western Siberia. The westerly migrations of these peoples commenced long before the advent of the Magyars in Europe, the earlier movement being through northern Russia, and proceeded as far as the Baltic coast, Finland and Lapland; the Lapps perhaps were pressed up into their inhospitable Arctic Circle settlements by the fighting folk of the more fertile lands. Pockets were left in Russia, but as in the case of the Samoyed, these were frequently pressed northwards into even less happy climes than those from which they had set out. Fighting, and pressure from more easterly warlike tribes undoubtedly caused these eruptions into Europe, as in the case of the Magyars who first paused in the Urals after leaving the mother country, proceeded to the Volga and came to rest in those territories

now known as the Bessarabia, Moldavia and Bukovina. They were now joined by Turkish folk, but of the seven tribes which banded together under Almos, the head of the Magyar tribe which gave its name to the people when they moved on again, the bulk were Ugrians. A small, neatly built and wiry people, with chestnut hair and grey eyes, they were fine horsemen and great fighters, yet they were tractable and accepted the leadership of the Turkish clan, dark-haired men speaking a different tongue. When they descended on to the Hungarian Plain, led by Arpad, who founded the first dynasty, the Ugrian element, finding the conditions similar to those of their late home, continued to live the life of their ancestors, fishing, hunting and tending cattle, and to-day the terms used in connection with these pursuits are of Finno-Ugrian origin, while the agricultural terms are Turco-Tatar. The Magyars are a round-headed brachycephalic people, and have a very lively sense of race, which has helped them through many difficulties.

THE "CLEAN-ROOM" IN A HUNGARIAN FARMHOUSE.
The peasants reserve this room for guests, and on the bedstead the family embroidered linen is seen piled to the ceiling. The "clean-room" is probably of religious origin.

Perhaps the above outline, though superficial, will give some idea of the people of the Hungarian Plain who, while preserving their habits and customs, language (despite attempts to repress it and the almost general use of Latin at one time), and ways of living, have shed all outward signs of Asiatic origin as commonly held. True, one will find chestnut hair and grey eyes, and on the Puszta short, wiry men, with tanned skin and quaint ancient ways of regulating life, but through this one cannot distinguish anything but an intelligent people clinging to traditions which are a part of their very being. Myths and stories, too, go back to the steppes, and the troubles with Bulgar and Pecheneg, but little further. Love of the hunt and the horse is as strong in Hungary to-day as a thousand years ago, when the dashing Magyar horsemen ranged as far as Burgundy in the west, Otranto in Italy, and carried their forays under the very walls of Constantinople. From these wild horsemen we get the light cavalry called Hussars, and in all likelihood it was the Magyar who made the stirrup known to the Aryan peoples of Europe. In their love of hunting and horses the Hungarian exhibits characteristics which have their counterparts in Great Britain, and it is perhaps natural that the people look towards England with the greatest friendship and desire for intercourse. Many British institutions have been introduced into Hungary, chiefly by that fine man Count Stephen Szechenyi, and Hungarians will never forget the welcome given here to the liberty-orator, Louis Kossuth. In the history of the land one also finds many parallels with incidents in British economic and social developments, one in particular being worth mention.

In 1222, that is seven years only after King John was forced to put his hand to Magna Charta at Runnymede, King Andrew III. at Szekesfehervar, issued the Golden Bull, which similarly put a restraint on the Royal prerogative and set the seal on the constitution of the country.

The clan system is still preserved in Hungary, the old clans being built up from the great families whose heads were leaders when the hordes of Arpad took possession of the Plains. But besides the tribal clans of the Magyars there are those pockets of other blood already referred to, and in the preservation of racial characteristics these have formed other clans; thus we have the Swabians, and the Sokacs, the latter a Serbo-Croat people settled in the south, principally near Pecs, whose ancestors were driven out of Bosnia before the Turks during one of the periodic invasions of Central Europe, and found refuge and comparative sanctuary on the lower Hungarian plains. Most interesting of these "clans" is the Matyok of Mesökovesd, at the foot of the Matra mountains. A Kun-Tatar people, they take their clan name from King Matyas (or Mathias) who favoured them. They are an extremely artistic people, of a few thousands all told, and they only very rarely marry outside the clan; the schoolmaster of the village told me that within his recollection not a single case had occurred of a Matyo

marrying an outsider. And yet they are a fine race, both men and women, intelligent and well set up. The men sometimes attain to 6 ft. 6 ins., and 6 ft. is comparatively common—in great distinction to the true Magyar who is short, inclined frequently to stockiness, though always lithe. The Matyo, like the pure Magyar, is rather slender and lissome. The moral standard is a high one, and should there be a falling away from the standard on the part of a young couple, I was told that the young man is the one to be ostracised by the clan, and not the girl, though a girl who has erred looks forward to unmarried life. This is in itself punishment enough among a people who regard marriage as the pivot of all things. The young fellow looks forward to the wedding day as a stepping-stone to manhood. He then attains manhood, and can enter the councils of the elders; until then he must do the work of a boy, which to these early maturing folk is abhorent. Marriage, therefore, a matter of arrangement between two families and lacking the preliminary country-lane courtship of more westerly peoples, is decided on at an early age.

A PEASANT WEDDING

Bride and bridegroom of the Bessenyös clan from the south Balaton district. The embroidery of the groom's great sleeveless coat is sometimes the work of the man himself. This garment and the petticoat trousers are worn by all Magyar peasantry.

The Matyok are especially noted for their splendid embroideries. All over Hungary the womenfolk weave linen and embroider it during the dark winter months when they cannot work in the fields, but in and about the tiny township of Mesökovesd the men too ply the needle, and, indeed, the finest designed and worked Matyo embroideries are done by the men. There are about eight or nine main motives incorporating the Magyar tulip as a base, and with these hundreds of different designs are worked out in ever-varying combinations of colours according to the instinct and taste of the worker. The motives are probably many hundreds of years old, and it is extraordinary how purely they persist; but the Matyok have no guide-books; the art is handed down traditionally, and the peasants work mainly by instinct. I would attribute much to developed instinct, for I have seen an old woman designing with a yellow crayon on a piece of black canvas material with tremendous speed, freehand, but unfailingly working to the desired end; and repeating the performance from the same centre time and again without copying any of the other designs. This old lady told me she had not the faintest idea when she started what the result would be, and yet she unerringly finished her design without once having to delete a line or go back to alter or add a stroke.

While some of this embroidery is used for house-interior decoration, most of it is for the embellishment of dresses, in the case of the men for the bottoms of the black aprons they wear and the full sleeves of their light blue blouses. The girls have shawls and other wearing apparel so decorated; their skirts are flounced and sway like concertinas, while the blouse sleeves are ruffled. Unmarried girls braid their hair, but the young married women wear silk handkerchiefs hung over a stick about a foot long, which is fastened on to the hair on the top of the head with a pad. Often a girl will, on festive occasions, wear dresses and embellishments worth anything up to two hundred pounds. With the Matyok, as with Magyar clans, garments are the outward signs of the peasant's wealth, and even in the hot summer Magyar girls will wear as many as ten, twelve, and perhaps fifteen petticoats, which billow out as they walk giving them the appearance of quaint Dresden figures come to life. These dresses are probably heirlooms to some extent, for the clothes, together with the linen and embroidered material kept in the "clean-room," and the painted plates on the kitchen walls, go to form the dowries when the girls marry. The "clean-room," by the way, is significant. Each "Tanya," or sundried mud-brick farmhouse, has a parlour which is reserved for guests. In this room there are frequently a couple of wooden bedsteads piled to the ceiling with linen, sometimes beautifully embroidered, also a chest of drawers, and the "tulip"

chest, a large painted clothes box with the tulip design painted on it. The beds are not to be slept in. Only on rare occasions to honour an important guest will they be used; indeed, they are reserved for the "honoured guest," and though the peasant will not be able to tell one who this may be, I feel that the reservation of these beds arises from early religious traditions, and is for the re-appearance of the "Christ." I have found something similar in other out-of-the-way places in Europe, and even in Wales, though in modern times I think that there it has more to do with the possibility of accident and sudden death in quarry and mine.

Turning for a moment to archaeology in Hungary, the recent finds at Pitvaros may teach us a deal about the earlier life of the plains. While cutting a road in the light soil between Pitvaros and Ambrozfalu, workmen unearthed a number of graves, apparently of early Bronze period. I happened to be in the neighbourhood, and the notary of the village took me to see the graves and their contents. All the material is now being carefully studied at the museum at Szeged. It is to be hoped that the result will soon be published to the world, and that new light will be shed on the pre-history of this part of the great river basin, which some regard as the birthplace of European civilization.

It was in mid-Hungary, on the Hortobagy Puszta, that wide uncultivated moor given over to the huge wide-horned cattle (descendants of those cattle which dragged the rude wagons of the migrating Magyars) and the troops of untamed horses, that I found the greatest personal interest. Of this strange territory, where the primitive life has altered but slightly since the days of Arpad, I hope to give some account in a subsequent article.

Among the Stars: A Monthly Commentary.

By A. C. D. Crommelin, D.Sc., F.R.A.S.

THE FACE OF THE SKY FOR MARCH.

We have reached the month of the vernal equinox; the map shows Regulus on the meridian, and Orion "sloping slowly to the west." Virgo, Bootes, and Lyra are coming into view. The "Pointers" in Ursa Major are nearly overhead. The only planet within the limits of the map is Neptune, which is $1\frac{1}{2}°$ west and 40′ north of Regulus. Saturn may, however, be observed in the south-east at a later hour of the night.

THE FACE OF THE SKY AS SEEN FROM LONDON at 10 h. sidereal time; on 7th March at 11 h. p.m., on 22nd March at 10 h. p.m.

New Study of the Sun.

Half a century ago Richard A. Proctor was famous as an astronomical lecturer and writer, having a notable gift for expressing difficult conceptions in attractive and intelligible language. His books may still be read with profit by astronomical students, but, of course, the great increase in astronomical knowledge since they were written renders them somewhat out of date. His daughter, Miss Mary Proctor, is carrying on the family tradition, and is engaged on a series of popular works on the Romance of Astronomy, of which *The Romance of the Sun* (Harper and Brothers. 7*s.* 6*d.*), is the latest instalment. The introduction sketches the advance in knowledge of the sun from the earliest times; the following chapters deal with the difficult problem of the sun's distance; the various transits of Venus, the expedition of the Gills to Ascension, in 1877, for observing Mars, and the Eros campaign in 1900, 1901, are described in an interesting manner, with many human touches. Then we have the exposition of solar physics, our knowledge of which has been enormously advanced by the spectroheliograph, independently devised by Hale and Deslandres. There are excellent reproductions in the book of photographs both of the sun's disc and of the chromosphere taken with this instrument. Then follows the story of the corona and of total eclipses of the sun. The author has herself taken part in a number of eclipse expeditions, and narrates her experiences very vividly. In particular, she observed the British totality of June, 1927, from an aeroplane; there are so few records as yet in astronomical annals of eclipses observed in that manner that this section is particularly interesting.

Two small slips should be corrected: P. 184, read 4.58 for 2.58; p. 195, Mr. Shackleton observed the eclipse of August, 1896, from Nova Zembla, not from Vadso.

Researches on Winding Rivers.

By F. J. North, D.Sc., F.G.S.

Geological Department, National Museum of Wales.

Meandering streams are a favourite subject for poets. As a rule, however, their work suggests that in common with most of us they are not familiar with the cause of these occurrences. The unusual photographs the author has obtained show very clearly examples of deserted river beds in a valley floor.

THE descent to sea-level from its source in the mountains imparts to a stream a certain amount of energy, which is expended in developing a valley. Near its source a stream usually runs down steep declivities, and the water moves rapidly. Swiftly flowing water has considerable power of transportation, and it carries along mud, sand, and sometimes pebbles, by means of which it wears away the rocks over which it flows, thus tending to make a steep-sided valley, the cross section of which resembles a letter V, with the river flowing at the bottom.

As the stream bed is worn down nearer to sea-level, the rate of descent diminishes, and the water moves more and more slowly; its transporting power is reduced, and some of its load is dropped; its power to wear away its bed is considerably curtailed, and the stream is easily deflected from its course.

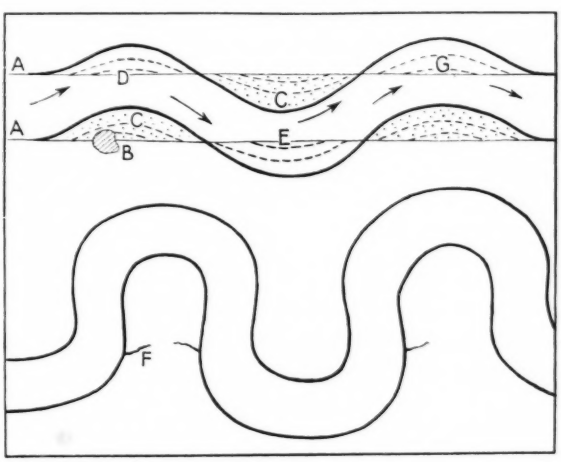


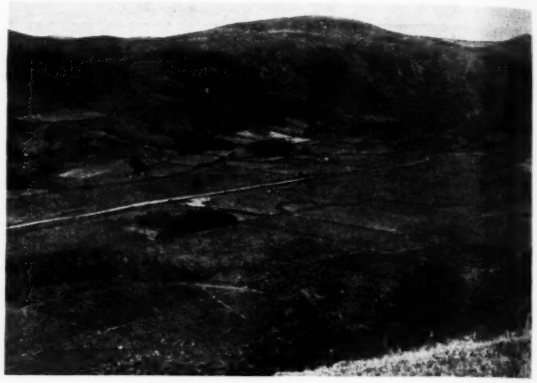
FIG. 1.
HOW MEANDERS DEVELOP.
Owing to a deflection in the current, one bank of a river is worn away and a sandbank is formed on the opposite shore. Details are given in the text, which also describes the development of tributaries shown in the lower part of the diagram.

Differences in the hardness of the material forming the banks, or comparatively small obstructions, are sufficient to cause a slow-moving stream to cross its direct course, deflecting the current towards one bank, which is, in consequence, worn away. At the same time the velocity on the side where the obstruction occurred is checked, and some of the solid material which the water holds in suspension tends to be dropped there, so that once a curve has been initiated it tends to increase its sweep as material is moved from one bank and is deposited on the other.

In the diagram (Fig. 1) the lines AA are intended to represent the banks of a stream following a straight course, B is an obstruction which deflects the current, and C is the beach-like accumulation of sediment formed on the bank opposite to that which is being worn away. Immediately a concavity is formed in one bank (D), the current is directed towards the opposite bank (E) and from thence to G, with the result that if a curve develops at one spot, the tendency to become sinuous is transmitted down the stream, and the development of curves or meanders may continue until the distance between two points in the river's course may be only a small fraction of the length of the channel separating them. As a result, if travelling in a boat, one appears, over and over again, to be approaching a spot that was passed some time before, or if travelling by train one crosses and re-crosses a stream, as is the case near Bedford where the railway crosses the Ouse seven times in as many miles. Hereford and Ross are only about eleven miles apart, but between the two towns the water of the Wye travels twenty-six miles and flows in turn towards every point of the compass.

The curves are called meanders, and the habit, meandering, after the name of a river in Asia Minor which follows a particularly sinuous course. When the stage indicated in the upper diagram in Fig. 1 has been reached, small tributaries may develop (F), still further reducing the barriers which keep the water in its course, and there will be a tendency, especially during floods, for the water to break through the narrow necks of land, thus taking a more direct course.

Since in passing round the bend the stream travels a considerable distance, there will be a difference of level between the ends of the new direct channel,



FIGS. 2 AND 3.

TWO VIEWS OF THE DYSYNNI RIVER, NEAR TOWYN, NORTH WALES, SHOWING OX-BOW LAKES AND DESERTED STREAM COURSES.

These photographs were taken from almost the same spot, that on the left, looking down-stream, and the other looking up-stream. An ox-bow lake is seen in Fig 2, as a crescent-shaped depression cut off from the main stream, while near the present straight channel in Fig. 3 are two deserted stream courses.

and the rate of flow will be, for a time, accelerated. The increased energy is accompanied by greater transporting power, and the new channel is rapidly increased in size until it takes the whole flow. In this way the old curves are deserted; their ends become blocked by accumulations of sand or mud, and they give rise to crescent-shaped lakes. These in time become swampy patches, which, by the growth of vegetation and the accumulation of sediments carried by the wind and rain, are gradually converted into parts of the general meadowland, to be distinguished only as slight depressions in the surface, or by differences in the colour of the vegetation. In many cases such deserted meanders cannot be detected by an observer on the ground, but they are clearly visible from a height.

The Dysynni River, which flows from Talyllyn Lake in North Wales and enters the sea near Towyn affords an excellent opportunity for studying the development of meanders, and the valley floor retains traces of deserted stream channels much more distinct than is usually the case.

The accompanying photographs (Figs. 2 and 3), were taken from an elevation of about 800 feet on the side of Foel Wyllt, which forms the south-eastern side of the valley about four miles from its mouth. They were taken from almost the same spot, one looking down-stream and the other looking up-stream. On the left hand side of Fig. 2 the river is seen to swing in great curves around the parkland and woods of Peniarth, whilst on the right hand side are two deserted curves. One is still connected with the main stream, but the other has been entirely cut off by the deposition of sediment, and is represented by a crescent-shaped depression containing a small lake; by deserting these two curves the river has shortened its course considerably.

In Fig. 3 the river follows a straight course for about a mile, but its former sinuous course across the plain is indicated by slight depressions, rendered conspicuous by differences in the appearance of the vegetation. The junction between the present course and the old one is marked by a small lake, separated from the main stream by a narrow barrier. A still older deserted course is seen in the foreground.

The River Towy, a few miles before it reaches Carmarthen, affords excellent examples of the crescent-shaped lakes so characteristic of a meandering river that frequently changes its course. Some of the deserted channels are still connected, at one end, with the main stream, whilst others have been silted up at both ends and are completely isolated (see Fig. 4): by the Americans such lakes are called "ox-bow" lakes. Meanders are particularly well-developed along the Mississippi; for instance, some distance north-west of New Orleans the river makes a circuit of twenty-six miles and returns to a point less than a mile from where the curve commenced.

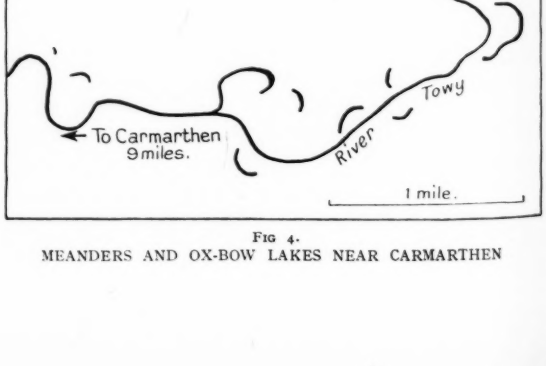


FIG 4.

MEANDERS AND OX-BOW LAKES NEAR CARMARTHEN

As a stream moves to and fro across its valley in the course of its meandering, the sand and mud it has brought down from the hills is shifted and re-deposited over and over again, and, being enriched by the remains of vegetation which decayed upon its surface, it will, if adequately drained, provide very fertile soil. In many cases the floor of such a valley is highly cultivated, while the hills that rise abruptly on either side are clothed only with their natural vegetation.

When Robert Montgomery wrote :—

> "The soul, aspiring, pants its source to mount,
> As streams meander level with their fount."

he was severely criticized by Lord Macaulay, who described the couplet as the worst similitude in the world; but although it is perfectly obvious that having once started on its way to the sea, a river can never again run level with the spring that gave it birth, it is at the same time a matter of common knowledge that the phenomenon of meandering is best displayed when a river flows in a broad valley over a surface that, as far as the eye can judge, is almost flat.

FIG. 5.
THE DYSYNNI RIVER APPROACHING THE SEA.
Meanders are most frequently formed as a stream approaches the sea, when the gradient of its bed and its velocity are least.

Local conditions may give rise to broad, gently sloping valley floors in various parts of a river's course, but meanders are most frequently developed when a stream approaches the sea (Fig. 5), because it is there that the gradient of its bed and the velocity of its water are least.

Correspondence.

AMUNDSEN'S AUTOBIOGRAPHY.

To the Editor of DISCOVERY.

SIR,

The passages concerning Stefansson in Roald Amundsen's "My Life as an Explorer," commented upon in your January issue, are not nearly so surprising as others concerning Scott in the same volume.

Stressing the advantages of a base-camp placed, as his was, on the Ross Barrier, Amundsen writes: " . . . Scott's choice of a site (for his base-camp) on the mainland to the west was an essential factor in his inability to return in safety from the Pole." Scott's base was on Ross Island, at least forty miles from the mainland. The writer maintains that the adverse weather conditions encountered by Scott were due to the proximity of his base and route to the mainland, but seems to overlook the fact that his own base at the Bay of Whales was not very far from King Edward VII Land, and that he also had to cross the mountains and traverse the plateau, in either of which regions, according to his contention, he might well have encountered bad weather.

Amundsen, writing that "Scott and his companions died . . . from actual starvation, because of their inability to provide adequately for food on the return journey," cannot have read these passages in Scott's "Message to the Public": "Every detail of food supplies, clothing and depots . . . worked out to perfection. We arrived within eleven miles of One Ton Camp with fuel for one last meal and food for two days"—in spite of the serious delays caused by the illness and loss of Edgar Evans, and later by the incapacitation of Captain Oates.

Any person unfamiliar with the history of Scott's last expedition, and with the causes contributing to the disaster, could not but infer from Amundsen's words that the latter was due to faulty planning. He draws an unfair contrast, and writes in another chapter: "Our success in attaining the Pole was due to the correctness of our planning." One cannot read Amundsen's "The South Pole" without admiring the constant thoroughness and scrupulous attention to detail, both at the base and on the journey, but what seems far more evident was his wonderful luck, in weather conditions, snow surface, and freedom from serious accidents and ill-health. The route he chose was quite unknown (Scott followed in his own and Shackleton's tracks as far as 88° latitude), and he might well have reached the mountains at an impassable point.

Yours, etc.,

Belfast, *6th February*. FRANK PIGOT.

PAGAN FESTIVALS IN MODERN EUROPE.

To the Editor of DISCOVERY.

SIR,

There are many common festivals held all over Europe and in our own isles which are of pagan origin. In my wanderings on the continent I have met with a number of these festivals, especially in the spring: the *Fasching* processions usual in Austria and Germany are, of course, relics of pagan worship, particularly in regard to Scandinavian and Germanic deities; perhaps, indeed, like the many spring festivals they go back even farther. Ignoring Yuletide and the Maypole, we have relics in Staffordshire, in the Shetlands, and parts of Scotland, of pre-Christian worship in present day local festivals, many of which have been carefully dealt with in various publications. The subject is fascinating, and I should very much like to hear more of actual local customs of this nature, on the continent especially. Perhaps readers of *Discovery* have occasionally had experience of such festivities, and would send me particulars addressed in your care.

Yours faithfully,

London, *21st February*. J. E. PRYDE-HUGHES.

Book Reviews.

The Ant People. By Dr. Hanns Heinz Ewers. Translated by C. H. Levy. (John Lane. 8*s*. 6*d*.).

The popularizing of biological science is of the utmost importance from the point of view of making governments and charitably disposed individuals supply the money necessary for the carrying out of research work, and yet we find that the scientific man who undertakes such work is rather looked down upon by his colleagues. Consequently, a number of popular biology books are written by people who have little or no scientific knowledge, and who therefore either give an account, frequently inaccurate, of the work done by others or who draw erroneous conclusions from things they have themselves observed.

The author of this book is a writer and a poet who has travelled in many parts of the world, and who has taken an unscientific interest in ants. He scorns "scientists," whom he describes as "pedants" (p. 108,) and says they "must not take it ill in us artists if we, on our side, take what the scientists tell us for what it is—stupid work, in which the gift of the artist to conceive something intuitively (some rare cases excepted) is altogether lacking" (p. 103).

I cannot but feel that there is a great deal of intuitive conception in the book, perhaps due to the fact that the author has "tried . . . to attain the soul state of the ant, as a poet may do perhaps better than a scientist" (p. 51). But if one accepts the book from this point of view, it will be found quite interesting, some parts, for instance, the description of the invasion of the author's house by wandering ants (*Eciton*) (pp. 78-85), being really good.

The extraordinary names given to different species of ants, *e.g.*, speckled stinging ants, narrow-breasted ants, Pharoah ants, etc., are fortunately explained in an appendix, although I only discovered this by accident, as there is no reference to it in the body of the book. The translation is not up to the style of the late Count Teixeira de Mattos or Alfred Sutro and, at times, the English is weak and the spelling American.

Frank Balfour-Browne.

History of Science Teaching in England. By D. M. Turner. (Chapman & Hall. 7*s*. 6*d*.).

Miss Turner, who was head of the science department at Wycombe Abbey School, has given us in compact form a most useful contribution to the science teacher's library. It is highly desirable that all who are engaged in science teaching should know something of its history, yet very often they know nothing. It is desirable for several reasons. Such knowledge will give them an explanation of the situation in which they find themselves in the educational system, it will show them the influences that have prevailed, the mistakes that have been made, and it will save them from being deceived by the proclamation of old doctrines as new gospel.

The book consists of ten chapters, the first four giving a very interesting and succinct account of the chief influences affecting natural science and the teaching of science from the time of Roger Bacon to the beginning of the nineteenth century. After this the history becomes more detailed, an account being given of the development of science teaching in the universities and other institutions for higher education. The outcome of Royal Commissions and State enactments is clearly set forth, and reference is made to the doctrines of the more modern prophets who have from time to time propounded what they conceived to be the true faith. To the accuracy of Miss Turner's history of science teaching in the last half-century the reviewer can, with mixed feelings, bear unhesitating witness: in its detail and its general trend it accords exactly with his own recollections. Miss Turner from her studies and experience has, of course, acquired opinions of her own upon the subject of science teaching, but where she turns from history to comment she is eminently fair. It is pleasant to be able to say amidst the present redundancy of new books for the science teacher that here is one which was really needed.

A. Smithells.

Animal Parasitology: An Introduction. By C. L. Walton and W. Rees Wright. (Sidgwick & Jackson Ltd. 6*s*.).

One of the central ideas in biology is that of the linkage of lives. It is an old idea this correlation of organisms, but it is the central idea of the new biology. Nothing lives or dies to itself; everything, as John Locke observed, is a retainer to some other part of Nature. It is common knowledge that widely separated forms of life are often linked together by being the two hosts of one parasite, of which we have an example in the sheep and the little water snail being the two hosts of the liver-fluke, which is the cause of very serious losses to farmers in many districts. Our authors give an interesting account of this parasite and the host snail, describing the latter also as "a serious potential danger, to be treated as such," but they do not tell us of the great service to human life which a study of these very relationships rendered. From a knowledge of this three-fold association, Dr. Leiper was able, during the Great War, to prove that a parasite inimical to human life called Bilharzia, and common in Egypt, spent its early stage inside a species of fresh-water snail. The microscopic larvae pass from the host into the water, and thence into the human body, entering through cracks and chafes in the skin. It is claimed that, by showing that the undesirable aliens can be kept back by good filters, and that the free-swimming stages die within thirty-six hours in water that is kept stagnant, Dr. Leiper's discovery has saved thousands of lives. The whole life-cycle of some parasites is thoroughly understood. Such knowledge is of the utmost importance, and may be of the greatest practical value. It is, too, of importance to realize that in many cases after a parasite has gained access to the host we may be helpless in expelling it, whereas removal of some of the conditions essential to its development outside the host may be practicable. Prevention is not only better but easier than cure.

The essential merit of "Agricultural Parasitology" is that it fills in the gap in the literature of the subject between the elaborate works largely of a technical character, but only partly informative, and the specialist writings, while at the same time it combines biological principles and practical application in a concise form. Its contents are restricted to the more important parasites of farm live stock in the British Isles, anything outside being included for the purpose of giving perspective or force to an argument. The liberal bibliography provided to each of the twelve chapters enhances its value to the student. The opinion may safely be expressed that the book is likely to prove a useful and important one, provided that it can secure the attention of the class to whom it appeals. As it is a work of more than academic interest, the working farmer should be grateful for this contribution towards the solution of one, at least, of the problems that menace his well-being.

H. H. W.

Social Life in the Animal World. By FR. ALVERDES. Translated by K. C. CREASY. (Kegan Paul. 10*s.* 6*d.*).

A most interesting book, based largely upon the observations of others, and one important point which one learns from reading it is the extraordinary difficulty one has in obtaining accurate and definite statements as to the habits of animals. The author classifies certain habits under headings, such as "seasonal mateships within the herd" and, after giving a number of would-be examples, he says, "In all these cases it is not certain whether we should speak of seasonal or permanent mateship." It is quite certain that many would dispute his classification in many cases.

On p. 22, under "Social instincts in solitary animals," reference is made to hibernating societies, though the author admits that it is uncertain whether there is any social instinct concerned. One gets, at times, the feeling that theoretical statements are made very positively, while what are supposed to be facts as to the habits of animals are stated without much conviction.

Up to p. 82, one has got used to the method on which the book is based, general headings with what are believed to be examples. From p. 83 to p. 106 we have a chapter on special animal sociology in which the habits of the best known social insects are described at length—an entirely different method. No conclusions are drawn, and there is no attempt to classify the habits or to discuss the origin of the social life. Following this, we return to general headings, the method adopted in the earlier chapters.

In some places the author brings forward theories, sometimes interesting ones, for instance, the "pecking order" in fowls (p. 125). In other places, as in the section on courtship and dancing (pp. 144-151), he deals merely with facts without referring to the fascinating theories on the subject.

The last chapter in the book, on "Human Sociology from a Biological Standpoint," covers only nine pages, and is rather disappointing as a summary of all that has gone before. "Tradition among men has above all this advantage over tradition among animals, namely, that it has a cumulative effect. . . . " (p. 201). Surely something might have been said here on the theory of "race memory" as accounting for the instincts of social insects?

However, it is very easy to pick holes in other people's work, especially when that work covers such a vast amount of ground.

FRANK BALFOUR-BROWNE.

Living Machinery. By A. V. HILL, M.A., Sc.D. (G. Bell & Sons. 7*s.* 6*d.*).

The younger generation is becoming wiser every day in the ways of machinery and, although good-naturedly tolerant, slightly superior towards anyone who betrays an ignorance of the anatomy of a carburettor or hesitates in distinguishing between the high and low tension system of a wireless set; yet, as a rule, boys and girls do not know much more about the machine in which they live than William the Conqueror did, and although they may be experts in geography, they are often very ignorant of what Sir Thomas Browne called "the Cosmographie of My Selfe." For this ignorance there is at least one very good reason, for the human machine is not one in which "the whole engine is exposed to view on removing the bonnet," nor are "all parts instantly detachable," but it is a machine whose working can be studied only indirectly and by means of elaborate and delicate apparatus. The amateur is therefore compelled, if he would learn about the human body, to make acquaintance with it at second hand, and this relationship with the subject is liable to be both dull and uninviting. Professor Hill removed this obstacle in the approach to physiology when he gave his Christmas lectures at the Royal Institution, by bringing with him his apparatus of investigation and revealing the workings of the machine under the eyes of his audience. With an X-ray installation he showed them the living heart as a shadow pulsating on a fluorescent screen, he broadcast the sound of its beating through a loud-speaker, and measured for them the electricity which it generates at each beat.

The lectures are here reproduced in book form, and give a fascinating account of the human engine; its efficiency is compared (quite favourably) with that of the artificial engines, and its "performance" is investigated on the cinder track and in the laboratory. But, although Professor Hill is especially interested in the human body as an engine which converts chemical energy into work, he shows it to us in its larger aspect as a co-ordinated machine, and devotes the first chapter of his book to the message carried by the nerves, that still mysterious impulse about which we seem to know everything except what it is. In a later chapter he gives a simple account of the complicated methods by which the interplay of our muscles is directed and controlled.

The story loses a little vividness in translation from the spoken to the written word, but the book is full of excellent illustrations—from Leonardo da Vinci to instantaneous photographs of high jumpers and diagrams of the latest intricacy for measuring the speed of the nerve impulse—which largely compensate for the loss of the rather diverting excitement of the actual demonstration. The book will be of greatest interest to those who attended the original lectures, enabling them to work out the details of the phenomena which were then presented to them in all the wonder of their unfamiliarity, but it will be also a stimulating introduction to the study of the human body for anyone whose interest in mechanics is not limited to things of metal.

F. A. H.

The Great Physicists. By IVOR B. HART. (Methuen. 3*s.* 6*d.*).

In this book the writer has attempted a great task, and his attack is very resolute. It is a review of historical physics and the work of famous physicists from the tentative philosophy of classical antiquity to the achievements of experimental and theoretical science of the last century. In writing such books, there must be an overwhelming temptation to allow the serious purpose of the book to be ousted by the insertion of amusing, valueless anecdotes of the mannerisms of the great physicists. The author has resisted such temptation, and his book may be regarded as a serious contribution to historical science. It will not appeal to the full-time physicist, whose training is not complete without a knowledge of the historical aspect of the science. But the earnest amateur, who treats science, not as a life-work, but as an absorbing hobby, will enjoy the book. The author has a knack of making dull elementary theory interesting—the knack, we think, is the administration of small doses at a time. The average reader of scientific books expects his reading matter to be like a good play—provocative ideas, interspersed with amusing relief. "The Great Physicists" fulfils these demands. One would have been more satisfied, perhaps, if the author had gone a little further, and indicated the gigantic bounds of progress made within the last decade. Possibly he holds the historian's view that history cannot be reviewed until it is a hundred years old.

J. F. L.

The Principles of Petrology : An Introduction to the Science of Rocks. By G. W. TYRRELL, Ph.D. (Methuen & Co. 10*s*.).

At the present time the mere mention of the word " evolution " tends at once to rivet the attention of the reader. It is a subject in which everyone is deeply interested, whether from the religious or the purely scientific standpoint, and Sir Arthur Keith's recent address to the British Association at Leeds showed that its discussion is still very much alive. Few of us, however, are familiar with the idea of evolution amongst the rock masses which form this globe. Dr. Tyrrell has laid special emphasis on this viewpoint of his subject, and the genetic principle is well to the fore throughout the book, which is the first of a series of geological works to be published under the general editorship of Prof. J. W. Gregory, F.R.S. With such a brilliant and useful beginning we look forward with interest to the remaining volumes.

The present instalment is the type of book specially suitable for readers of *Discovery*. It gives a clear and concise account of the present position of the science and rather aims at the explanation of general principles than the description of a multiplicity of illustrative examples. On the other hand, sufficient examples are introduced to explain fully this genetic standpoint, and the geologist will note with joy that Dr. Tyrrell has unearthed some new and refreshing references instead of using the hackneyed illustrations which appear with monotonous regularity in most textbooks.

From the standpoint of the advanced geologist Dr. Tyrrell is certainly at his best in the last section of the book, which is devoted to the exposition of metamorphic rocks. These are members of either the primary or secondary classes, which have been changed or metamorphosed by the action of great heat or pressure, thus producing new structures and minerals.

Not the least useful feature is the numerous footnote references to original sources of information, many of them of the type not usually found in a geologist's " stock-in-trade." We have noted a few errors in these, but such are inseparable from first editions and can be remedied in the future, for we have no doubt that Tyrrell's Petrology will soon be found on the bookshelves of all working geologists. F. S. W.

The Aerial A.B.C. and Commercial Air Line Gazetteer. (Aerial A.B.C. Ltd. 1*s*.).

In the early days of aviation, if anyone had prophesied the mere possibility of air liners flying to schedule all over the world, the notion would have been received with derision. But just as the first slender " Bradshaw " was the pioneer of modern railway guides, so world aviation now has its publication issued under the title above.

Time-tables, fares, freightage, rates, distances, air ports, aerodromes, and linked motor services are all classified in this compendium of flying, while there is also a list of agencies and receiving depots for goods, air-post rates, passport information, and everything that the potential " user of the air " requires to know. One of the most useful features is the clear maps with which this guide is illustrated, which in these early days of commercial aviation it is no small feat to have compiled.

Books Received.

Everyday Electricity. By JOSEPH R. LUNT. (The Macmillan Company. 7*s*.).

A System of Qualitative Analysis for the Rare Elements. By ARTHUR A. NOYES and WM. C. BRAY. (The Macmillan Company. 21*s*.).

A Study in Tubercle Virus, Polymorphism, and the Treatment of Tuberculosis and Lupus with Oleum Allii. By WILLIAM C. MINCHIN, M.D. (Bailliere, Tindall & Cox. 25*s*.).

The Earlier Inhabitants of London. By PROF. F. G. PARSONS, F.R.C.S., F.S.A. (Cecil Palmer. 10*s*. 6*d*.).

Pioneers of Wireless. By ELLISON HAWKS, F.R.A.S. (Methuen & Co. Ltd. 12*s*. 6*d*.).

William the Conqueror. By DORIS M. STENTON. (G. P. Putnam's Sons. 2*s*. 6*d*.).

Napoleon. By C. R. CLEARE, B.A. (G. P. Putnam's Sons. 2*s*. 6*d*.).

Joan of Arc and the Making of the French Nation. By M. ORLIDGE DAVIS. (G. P. Putnam's Sons. 2*s*. 6*d*.).

Religious Conversion : A Bio-Psychological Study. By SANTE DE SANCTIS. (Kegan Paul. 12*s*. 6*d*.).

The Stereoscopic Examination of Air Photographs. By LIEUTENANT M. HOTINE, R.E. (H.M. Stationery Office. 3*s*. 6*d*.).

Animal Biology. By J. B. S. HALDANE and JULIAN HUXLEY. (Oxford University Press. 10*s*. and 6*s*.).

The Locomotive God. By WILLIAM ELLERY LEONARD. (Chapman & Hall. 18*s*.).

The Nile and Egyptian Civilization. By A. MORET. (Kegan Paul. 25*s*.).

Food and Health. By A. BARBARA CALLOW. (Oxford University Press. 2*s*. 6*d*.).

Lares et Penates, or the Homes of the Future. By H. J. BIRNSTINGL, A.R.I.B.A. (Kegan Paul. 2*s*. 6*d*.).

This Airship Business. By E. F. SPANNER. (Williams & Norgate. 25*s*.).

Sovereignty : A Study of a Contemporary Political Notion. By PAUL W. WARD. (G. Routledge & Sons Ltd. 7*s*. 6*d*.).

Marc Lescarbot Nova Francia : A Description of Acadia, 1606. Translated by P. ERONDELLE, 1609. Introduction by H. P. BIGGAR, D.Litt. Edited by SIR E. DENISON ROSS and EILEEN POWER. (G. Routledge & Sons Ltd. 12*s*. 6*d*.).

Breaking Priscian's Head, or English as she will be Spoke and Wrote. By J. Y. T. GREIG, M.A., D.Litt. (Kegan Paul & Co. Ltd. 2*s*. 6*d*.).

Qualitative Analysis. By WM. WARDLAW, D.Sc., and FREDERIC WM. PINKARD, M.Sc. (Longmans, Green & Co. Ltd. 3*s*. 6*d*.).

The Origin of Instinct : A Study of the War between the Ants and the Termites. By E. BUGNION. Translated by C. K. OGDEN. Psyche Monographs : No. 1. (Kegan Paul, Trench, Trubner & Co. Ltd. 5*s*.).

English : From Piers Plowman to the Forsyte Saga. By JOHN L. YOUNG. Introduction by R. BRIMLEY JOHNSON. (W. & G. Foyle. 1*s*. 6*d*.).

Practical Psychology for Students of Education. By CHARLES FOX. (Kegan Paul. 7*s*. 6*d*.).

History of Radio Telegraphy and Telephony. By G. G. BLAKE, M.I.E.E., F.Inst.P. (Chapman & Hall. 25*s*.).

Atlanta, or the Future of Sport. By G. S. SANDILANDS. (Kegan Paul. 2*s*. 6*d*.).

The Biology of Insects. By GEORGE H. CARPENTER, D.Sc. (Sidgwick & Jackson Ltd. 16*s*.).

Man Rises to Parnassus. By HENRY FAIRFIELD OSBORN. (U.S.A. : Princeton University Press. $2.50. London : Oxford University Press. 11*s*. 6*d*.).

Physics in Medical Radiology. By SIDNEY RUSS, D.Sc., F.Inst.P., L. H. CLARK, Ph.D., F.Inst.P., and B. D. H. WALTERS, M.Sc., A.Inst.P. (Chapman & Hall. 12*s*. 6*d*.).

Tropical Agricultural Research in the Empire. By C. A. BARBER. Sc.D., C.I.E. (H.M. Stationery Office. 1*s*. 6*d*.).

Report on Development of Agriculture in British Guiana. By H. C. SAMPSON, C.I.E. (H.M. Stationery Office. 9*d*.).

Report of Development of Agriculture in Trinidad. By H. C. SAMPSON, C.I.E. (H.M. Stationery Office. 3*d*.).